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A SURVEY OF AVERAGE DRIVING PATTERNS
IN THE CHICAGO URBAN AREA

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A SURVEY OF AVERAGE DRIVING PATTERNS
IN THE CHICAGO URBAN AREA

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November 26, 1969

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INTRODUCTION

System Development Corporation (SDC) has performed a study to survey the characteristic use patterns of privately operated automobiles in the Chicago, Illinois urban area. The study was conducted under jointly sponsored research contracts to the National Center for Air Pollution Control, Department of Health, Education, and Welfare, and the Coordinating Research Council, Inc. The purpose of the study was to obtain data necessary to develop a composite average driving pattern that would serve as a basis for designing new test cycles for vehicle emission control devices.

During the study SDC installed automatic information recording devices -- called Tachographs -- in 199 privately operated automobiles volunteered by Chicago area residents. The data records from these instruments as well as information obtained from log books maintained by each of the volunteer participants have been reduced and analyzed. This document presents a discussion of the study results, and a comparison of these results with the findings of similar surveys conducted previously in Los Angeles, California, Houston, Texas, and Cincinnati, Ohio.

1 This report is published as Volume III of SDC document series TM-(L)-4119. Volume 0, A Survey of Average Driving Patterns in the Los Angeles Urban Area presents in addition to the Los Angeles survey findings a description of the survey technique as well as the data reduction and statistical analysis procedures. Since the technique and procedures used for collecting and analyzing the Chicago data are essentially the same as those employed for Los Angeles, reference is made to Volume 0 for information in these areas.

TABLE OF CONTENTS

	<u>PAGE</u>
INTRODUCTION	ii
<u>RESULTS OF STUDY</u>	1
TYPICAL DRIVING PATTERNS	1
<u>The Two-Trip Day</u>	8
<u>The Three-Trip Day</u>	10
<u>The Four-Trip Day</u>	16
<u>The Five-Trip-Day</u>	23
GENERAL RESULTS	29
<u>The Chicago Sample</u>	29
<u>Sample Biases</u>	29
<u>Data Collected</u>	31
<u>Daily Patterns</u>	31
<u>Trip Descriptors</u>	43
<u>Trip and Segment Distance</u>	43
<u>Trip and Segment Velocity</u>	43
<u>Trip and Segment Elapsed Time</u>	51
<u>Trip and Segment Idling</u>	51
<u>Elapsed Time Between Trips</u>	63
<u>Parking</u>	70
<u>Overnight Fuel Tank Readings</u>	71
<u>Use of Freeways Versus Surface Streets</u>	72
COMPARISON OF CHICAGO, CINCINNATI, HOUSTON, AND LOS ANGELES RESULTS	81
<u>N-Trip Day Patterns</u>	82
<u>Automobile Utilization</u>	82
<u>Trip Descriptors</u>	86
<u>Conclusions</u>	89

November 26, 1969

iv

TM-(L)-4119/003/00

TABLE OF CONTENTS (CONTINUED)

	<u>PAGE</u>
APPENDIX	A-1
<u>Sample Design</u>	A-1
<u>Participant Selection</u>	A-2
<u>Data Collection</u>	A-3

RESULTS OF STUDY

This chapter presents the results of the Survey of Average Driving Patterns in the Chicago urban area. The results are organized into three sections. The first presents a detailed description of the several average or typical¹ driving patterns that were developed from a statistical analysis of the survey data. The second section presents a summary description of the data base from which the typical patterns were derived. The third section presents a comparison between the Chicago results and the results of the surveys carried out previously in Los Angeles, Houston, and Cincinnati using statistical analytical techniques to determine similarities and differences in the driving habits of the citizens of the four cities.

TYPICAL DRIVING PATTERNS

SDC's intent in deriving the typical driving patterns described below has been to extract from a large amount of information collected during the survey a fairly detailed quantitative and qualitative description of those patterns which clearly stand out as typical. While the data base is large, it is not so large that the analyst can, with great confidence, probe very deeply into the intricacies of secondary or tertiary patterns. Nevertheless, in view of the scarcity of previous results in this area of study, particularly from the standpoint of enlisting the public's aid in the data collection effort, the results presented here present a substantial contribution to our knowledge of automobile utilization--even if they only serve to reinforce what have heretofore been intuitive concepts about how people drive their cars.

¹ SDC prefers the term "typical" to the term "average" since the latter has the connotation of an arithmetic mean which in the present case is not entirely appropriate. The typical driving patterns are, in most aspects of the analysis, derived from modes rather than means in the statistical sense.

A typical driving pattern is described in terms of a day's sequence of trips that all start at approximately the same time, have the same trip segment string (i.e., have identical patterns of freeway and nonfreeway usage), and can be explained by a reasonable scenario of driver behavior. The patterns described below are those which stand out clearly in the results of the analysis. Part of the description of each pattern is an indication of the percentage of the entire survey sample represented by the pattern as well as the percentage of the n-trip sample which is characterized by the n-trip pattern. Figure 1 shows the distribution of n-trip days for the seven days of the week.

Table 1 shows the distribution of complete weekdays and weekend days¹ upon which survey participants drove their cars on n-trips. In the Chicago survey, n varied from zero to 18 on weekdays and from zero to 22 on weekends. The table shows that the occurrence of days on which more than six trips were driven drops off quickly compared to days on which six or less were driven. Partly because of the dropoff in sample size as the number of trips increased, but more importantly because the potential number of trip patterns increases geometrically as the number of trips per day increases, patterns were discovered only for two-, three-, four-, and five-trip sequences.

Again, as in Los Angeles, Houston, and Cincinnati, no clear-cut patterns were discernible for weekend driving. The time distribution of weekend trips is quite different from that of weekday trips (see Figures 12 and 13). The incidence of n-trip days also varies considerably between weekend days and weekdays. To some extent this difference may be more marked in our survey due to the composition of the survey population. All participants in the survey were contacted through their place of employment. Consequently, the daily schedule imposed

¹ A complete day is one for which data were obtained for the entire day's operation or for which data on two half-days of operation were available and could be merged to make a single day's operation.



FIGURE 1
FREQUENCY OF N-TRIP DAYS BY DAY OF WEEK

TABLE 1

DAILY DISTRIBUTION OF COMPLETE N-TRIP
DAYS IN CHICAGO DRIVING PATTERNS SURVEY

[illegible]

upon a working employee tends to be reflected in the survey results. Weekday-weekend differences are discussed more fully in the General Results section of this chapter.

In analyzing the typical n-trip day patterns, differences in the occurrence of particular trip segment strings require that two alternative trips be considered as components of the pattern in certain cases. Also, two distinct patterns for the four-trip and five-trip days were discovered that require alternative descriptions.

The following sections of the chapter describe each sequence, or pattern, of trips in terms of a scenario and a table of values for such trip descriptors as start time, trip and segment distance, segment average speed, number of momentary stops (idles) per segment, idling time per segment,¹ route types, and purpose of trip. The quantities tabulated for start time, distance, average speed, number of momentary stops (idles), idling time, route type and purpose of trip are the mean values associated with trips and segments that are defined by the specified time slot, purpose, and trip segment string. Adjacent to these values are ranges within which at least 75 percent of the data lie. These ranges are obtained by examining a printout of the distribution of cases for each variable as specified by time slot, purpose, and trip segment string. In the printout, variables are grouped into class intervals. The class intervals used by the program are as follows:

¹ In the Los Angeles Survey a linear regression model was made to convert number of momentary stops to idling time. Because of the wide variance in measured idle time as a function of number of stops, we expressed reservations about this approach in the Los Angeles report. (See D. H. Kearin, R. L. Lamoureux, A Survey of Average Driving Patterns in the Los Angeles Urban Area, System Development Corporation, TM-(L)-4119/000/01A, June 2, 1969, pp. 1-56, 2-18.) In the Chicago analysis, as in the Cincinnati and Houston analyses, we have discarded the use of the regression model and have included as idling time only that which was actually recorded on the Tachograph disc (i.e., the summation of all idling periods in excess of 40 seconds). Therefore, in evaluating idle time figures, one must consider both the number of momentary stops, which indicate the extent of short idling periods of indeterminate length, and the mean idling time, which represent estimates of the expected sum of any extended periods of idling.

Distance: 1-mile intervals from 0 miles to 60 miles.
Average speed: 5-mph intervals from 0 mph to 75 mph.
Momentary stops: 1-stop intervals from 0 to 30 stops.
Idling time: 1-minute intervals from 0 to 10 minutes.

To calculate the 75-percent ranges for distance, speed, and idling time, the analyst starts with the class interval that contains the mean, and working away from that interval in both directions, sums the number of cases until he has included at least 75 percent of them. The number he accumulates in each direction depends on the way the data are distributed: For distributions skewed in the lower direction, more cases will be picked up below the mean; for symmetrical distributions, the range will be more balanced. The time slots used for grouping the data were agreed upon earlier by CRC¹ and SDC. Weekdays are divided into eight time slots, weekend-days into six. Table 2 shows the organization of the time slot structure.

TABLE 2
TIME SLOT STRUCTURE USED IN
CHICAGO DRIVING PATTERNS SURVEY

TIME SLOT NUMBER	TIME PERIOD (24 HOUR CLOCK)	
	WEEKDAY	WEEKEND
1	0000-0559	0000-0829
2	0600-0859	0830-1059
3	0900-1129	1100-1259
4	1130-1329	1330-1759
5	1330-1629	1800-2059
6	1630-1829	2100-2359
7	1830-2059	—
8	2100-2359	—

¹ CRC-APRAC Project Groups CAPE-5 and CAPE-10.

The time distribution of all trip start times is shown in Figures 12 and 13 in the General Results section of this chapter.

The elapsed time for each component trip of a typical trip pattern is based on completing the mean trip or segment distance at the mean average speed. The reason for calculating mean elapsed time from mean distance and mean average speed is twofold. First, as described in the pattern descriptions, certain trip distances are derived artificially so that no data on real elapsed time over these distances are available. Second, and more important, the Tachograph provides distance and elapsed time for each trip from which exact average speed values are calculated. The values of these three variables are, however, continuously distributed from the standpoint of the computer. In order to meet computer storage requirements and to obtain distribution information, these variables must be grouped or classified into the class intervals previously listed. Once this is done, mean speed, mean trip distance and mean elapsed time are no longer functionally related in exact terms since all calculations use the midpoint of the class interval to represent all the values within that interval. Therefore, the authors believe that the average speed and average distance are more "real" intuitively since they are descriptive of actual, not artificial, phenomena that occurred during the survey, and that elapsed time can best be calculated using the mean values for these variables rather than using the mean values for time and distance to calculate mean average speed. Variations over the ranges for distance and speed will, of course, cause differences in the elapsed time of the trip or segment.

A general description of the method used in deriving these patterns is contained in the Statistical Analysis section of Part III of the Los Angeles report.¹ The section on general results that follows the description of the typical trip patterns discusses in greater detail the quantitative basis for the patterns described.

¹ Ibid., pp. 3-1 to 3-16.

The Two-Trip Day

Figure 2 shows the time dependency distribution of all two-trip weekdays that occurred during the survey period in Chicago. The presentation is in the form of a trip-to-trip transition matrix. The matrix is set up as follows: All trips are assigned a time slot value based on the time slot into which one-half or more of the total trip time falls. These time slot values for all trips one and two on two-trip days were analyzed to determine into which cell of the trip-to-trip transition matrix the day's record would be counted. The time slot value for trip one established the row for the entry, the time slot value for trip two established the column. Therefore, if a trip one occurred in time slot two followed by a trip two in time slot six, the record for that day was associated with cell 26 at the intersection of the second row and the sixth column. In addition to the slot dependencies, the analysis also provided counts for purpose-to-purpose dependencies within each time slot cell. It is from these latter dependencies that the literal entries in Figure 2 indicating the typical purpose-to-purpose pairs are obtained. In Figure 2 and subsequent trip-to-trip transition matrices these literal entries are made only for cells with high frequency trip entries and then only if a particular purpose pair stands out.

From Figure 2, we see that the highest frequency count occurs in cell 26 with 83 two-trip days showing the transition. Of these 83, 74 show the purpose-to-purpose combination of a trip one, to work, followed by a trip two, to home. That this is a typical trip pattern is clear. Reinforcement is added by the fact that 10 trips in the adjacent cell 25 as well as five trips in cell 27 show the same purpose-to-purpose structure. If one assumes that the 10 in cell 25 represent people with early quitting times, say between 4:00 and 4:30 p.m., while the five in cell 27 represent overtime workers, then the analysis shows that between 74 out of 120 (62%) and 89 out of 120 (74%) of the two-trip days fit our typical pattern. This range represents between 9.2% and 11.1% of the total complete car-weekdays in the survey.

November 26, 1969

-9-

TM-(L)-4119/003/00

TO TIME SLOT		0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
FROM TIME SLOT	0000-0559	0	0	0	0	6	1	0	0
	0600-0859		0	0	1	10	83 W-H	5	2
			0900-1129	0	0	0	1	0	0
				1130-1329	0	0	0	0	4
					1330-1629	1	0	0	0
						1630-1829	1	1	1
							1830-2059	2	1
								2100-2359	0
TRIP ONE TO TRIP TWO									
TOTAL TWO-TRIP WEEKDAYS: 120									

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 2
TWO-TRIP WEEKDAY TRANSITION MATRIX

The values for the typical two-trip pattern are shown in Table 3. In the first column, entitled Trip Number, the letter "A" represents a nonfreeway trip while the letter "B" represents a freeway trip. The trip-to-work in time slot two on weekdays is more likely to have a trip segment sequence of nonfreeway only rather than nonfreeway/freeway/nonfreeway (the survey contained 341 of the former, 209 of the latter). However, because a substantial number of work trips in this time period do have the nonfreeway/freeway/nonfreeway configuration, we believe that both should be accounted for. The Chicago data tend to indicate that weighting factors of two-thirds and one-third should be assigned respectively to the N and the NFN trip segment string work trips in time slot two. This weighting assignment is also used in the subsequent three-, four-, and five-trip day patterns. The data for return trips home in time slot six are confused by the incidence of return trips from origination points other than work. Realizing that the decision is arbitrary, we have chosen to assign the same structure to the return trip from work that is shown in the morning trip to work. Therefore, the distances shown in Table 3 for the evening trip are the same as those in the morning trip. The average speeds for both trips, however, are those characteristic of the time slot, purpose, and trip segment string described. The elapsed times are calculated from these values. The values for trip stops engine running and idle time are adjusted to be proportional to the average distance traveled.

The Three-Trip Day

Figures 3 and 4 show the two trip-to-trip transition matrices for complete three-trip days in the Cincinnati survey. The matrix in Figure 3 shows the transition from trip one to trip two; that in Figure 4 from trip two to trip three.

The predominant transition in the first matrix is from a first trip in time slot two to a second trip in time slot six. In addition, there is a transition of a secondary importance for the adjacent cell representing a second trip in time slot five. Of the total of 55 trips in cell 26, 28 represent the purpose-

TABLE 3
THE TYPICAL TWO-TRIP DAY PATTERNS
(REPRESENTS 62% - 74% OF ALL TWO-TRIP DAYS, 9.2% - 11.1% OF ALL COMPLETE CAR WEEKDAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME		MEAN ELAPSED TIME (MIN)	DISTANCE (MILES)		AVERAGE SPEED (MPH)		NUMBER OF STOPS (IDLES)		IDLE TIME (MIN)	
				MEAN	RANGE*		MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**
1A	WORK	1	NF	0722	0642 - 0802	20.1	6.9	0.1 - 11.0	20.5	15.0 - 30.0	8.6	2.0 - 15.0	0.6	0.0 - 1.0
1B	OR: WORK													
		1	NF	0715	0633 - 0757	8.8	3.5	0.1 - 7.0	24.2	10.0 - 40.0	4.9	2.0 - 8.0	0.4	0.0 - 1.0
		2	F			14.8	8.5	2.0 - 13.0	34.5	20.0 - 50.0	1.3	0.0 - 2.0	0.0	0.0 - 1.0
		3	NF			10.2	4.5	0.1 - 7.0	26.6	15.0 - 40.0	4.6	0.0 - 8.0	0.2	0.0 - 1.0
						33.8	16.5				10.8		0.6	
TRIPS 1A AND 1B OCCUR IN THE RATIO OF 2 TO 1 RESPECTIVELY														
2A	HOME	1	NF	1713	1638 - 1748	19.8	6.9	0.1 - 11.0	20.9	15.0 - 35.0	9.5	4.0 - 15.0	0.8	0.0 - 1.0
2B	OR: HOME													
		1	NF	1701	1632 - 1730	10.5	4.5	0.1 - 7.0	25.7	10.0 - 40.0	7.0	4.0 - 11.0	0.2	0.0 - 1.0
		2	F			15.1	8.5	2.0 - 13.0	33.7	15.0 - 50.0	1.6	0.0 - 3.0	0.1	0.0 - 1.0
		3	NF			8.0	3.5	0.1 - 7.0	26.2	10.0 - 40.0	3.7	0.0 - 8.0	0.1	0.0 - 1.0
						33.6	16.5				12.3		0.4	
TRIPS 1A AND 1B OCCUR IN THE RATIO OF 2 TO 1 RESPECTIVELY														

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

November 26, 1969

-12-

TM-(L)-4119/003/00

TO TIME SLOT		0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
FROM TIME SLOT	0000-0559	0	1	1	0	2	0	0	0
	0600-0859		6	1	4	12	55 W-S	3	0
	0900-1129			1	0	0	1	0	0
	1130-1329				1	2	0	0	0
	1330-1629					2	1	0	0
	1630-1829						1	2	1
	1830-2059							0	0
	2100-2359								1

TRIP ONE TO TRIP TWO
TOTAL THREE-TRIP WEEKDAYS: 98

LEGEND
H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 3
THREE-TRIP WEEKDAY TRANSITION MATRIX

November 26, 1969

-13-

TM-(L)-4119/003/00

TO TIME SLOT		0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
FROM TIME SLOT	0000-0559	0	0	0	0	0	0	0	0
	0600-0859		0	0	0	0	6	0	1
	0900-1129			1	0	1	1	0	0
	1130-1329				0	2	1	0	2
	1330-1629					5	8	4	1
	1630-1829						27 S-H	23 S-H	8
	1830-2059							3	2
	2100-2359								2

TRIP TWO TO TRIP THREE
TOTAL THREE-TRIP WEEKDAYS: 98

LEGEND
H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 4
THREE-TRIP WEEKDAY TRANSITION MATRIX

to-purpose transition of work to shopping. In addition, four of the trips in cell 26 also have this pattern. The morning-to-evening, work-to-shopping pattern between trips one and two therefore represent between 29% and 33% of all three-trip days in the Cincinnati survey.

The second matrix, Figure 4, shows the highest frequency of transitions between trips two to three occurring within time slot six. A secondary pattern also occurs in cell 67 which correlates with the overall three-trip day pattern. In cell 66, 19 transitions out of 27 are from shopping to home; and in cell 67, nine out of 23. Therefore, we believe it reasonable to state that the three-trip day pattern represents 29% of the three-trip days (28 out of 98 such days), or 3.5% of the complete car-weekdays in the survey.

Table 4 contains the values describing the typical three-trip day pattern. In calculating results for the trips 2A-3A combinations, the total distance of trip 1A is allocated between trips 2A and 3A in proportion to the mean distances of shopping trips and home trips in time slot six.

The distribution of trip purposes and trip segment strings in time slot six shows a high degree of correlation between shopping trips and the nonfreeway only segment structure. There are 246 trips in this category but the "expected" frequency is only 225. In this case the expected frequency is obtained by dividing the total number of shopping trips in time slot six according to the division of all trips in time slot six between the freeway and nonfreeway configurations. As a consequence of the correlation between shopping trips and the nonfreeway trip structure, we believe that the destination for the shopping trip is reached before rather than after the driver enters the freeway portion of his return trip home. Therefore, in allocating the distance between trips 2B and 3B, the first segment of the trip is divided in proportion to the mean distances of nonfreeway shopping trips and the first leg of nonfreeway-freeway-nonfreeway home trips in time slot six. Average speeds shown and used in calculating elapsed time are those of the appropriate trip purpose and time slot. Engine running stops and idle time are assigned in proportion to total trip distance.

TABLE 4
THE TYPICAL THREE-TRIP DAY PATTERNS
(REPRESENTS 29% OF ALL THREE-TRIP DAYS, 3.5% OF ALL COMPLETE CAR-WEEKDAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME		MEAN ELAPSED TIME (MIN)	DISTANCE (MILES)		AVERAGE SPEED (MPH)		NUMBER OF STOPS (IDLES)		IDLE TIME (MIN)	
				MEAN	RANGE*		MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**
1A	WORK	1	NF	0722	0642 - 0802	20.1	6.9	0.1 - 11.0	20.5	15.0 - 30.0	8.6	2.0 - 15.0	0.6	0.0 - 1.0
1B	OR:													
	WORK	1	NF	0715	0633 - 0757	8.8	3.5	0.1 - 7.0	24.2	10.0 - 40.0	4.9	2.0 - 8.0	0.4	0.0 - 1.0
		2	F			14.8	8.5	2.0 - 13.0	34.5	20.0 - 50.0	1.3	0.0 - 2.0	0.0	0.0 - 1.0
		3	NF			10.2	4.5	0.1 - 7.0	26.6	15.0 - 40.0	4.6	0.0 - 8.0	0.2	0.0 - 1.0
						33.8	16.5				10.8		0.6	
TRIPS 1A AND 1B OCCUR IN THE RATION OF 2 TO 1 RESPECTIVELY														
2A	SHOP	1	NF	1723	1647 - 1759	7.5	2.8	0.1 - 5.0	22.4	15.0 - 35.0	4.2	0.0 - 8.0	0.2	0.0 - 1.0
3A	HOME	1	NF	1754	---	11.8	4.1	0.8 - 8.0	20.9	15.0 - 35.0	5.7	0.0 - 9.0	0.5	0.0 - 1.0
	OR:													
2B	SHOP	1	NF	1723	1647 - 1759	6.4	2.4	0.1 - 5.0	22.4	15.0 - 35.0	3.6	0.0 - 7.0	0.2	0.0 - 1.0
3B	HOME	1	NF	1752	---	4.9	2.1	0.1 - 5.0	25.7	10.0 - 40.0	3.8	0.0 - 6.0	0.1	0.0 - 1.0
		2	F			15.1	8.5	2.0 - 13.0	33.7	15.0 - 50.0	1.6	0.0 - 3.0	0.1	0.0 - 1.0
		3	NF			8.0	3.5	0.1 - 7.0	26.2	10.0 - 40.0	3.7	0.0 - 8.0	0.1	0.0 - 1.0
						28.0	14.1							
TRIP COMBINATIONS 2A - 3A AND 2B - 3B OCCUR IN THE RATION OF 2 TO 1 RESPECTIVELY														

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION
** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

The Four-Trip Day

Figures 5 through 7 show the three trip-to-trip transition matrices for the four-trip day. Two typical patterns for the four-trip day were discovered: The first is distinguished by a pair of trips in the evening, the second by a pair of trips during the noon period.

Evening Patterns

Cell 26 in Figure 5 shows that 76 cars transitioned from time slot two to time slot six. Of these, 57 transitioned from a work trip to a home trip. Turning to Figure 6, we see that these 57 cars were among the 79 cars that transitioned to a third trip in time slots six and seven. These 79 transitions included 38 home-to-shopping trips, and 16 home-to-recreation trips. Figure 7 shows that third trips in time slot six transitioned primarily to fourth trips in time slots six and seven. Third trips in time slot seven transitioned to time slots seven and eight. Of the 23 of these fourth trips in time slot six (cell 66), 17 were return trips from shipping, three from recreation. Of the 44 fourth trips in time slot seven (cells 67 and 77), 31 were return trips from shipping and ten were return trips from recreation.

From these data we deduce the typical Four-Trip Day (Evening) Pattern, shown in Table 5. Trip one is to work in time slot two. Trip two returns home in time slot six. Trip three is a shopping, recreation or school trip in time slot six or seven. Trip four returns home in time slot seven. Trips one and two are divided between the two-trip segment structures used in the previous two patterns in the same two-to-one ratio. The trip segment structures of the evening trips are all nonfreeway trips.

The minimum number of car-days that show the typical four-trip evening pattern (using the number of home-to-shop or recreation trips in cells 66 and 67 of Figure 6) is 54. This represents 37% of all four-trip days and 6.7% of all car-weekdays in the survey.

November 26, 1969

-17-

TM-(L)-4119/003/00

TO TIME SLOT		0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
FROM TIME SLOT	0000-0559	0	3	1	0	2	1	1	0
	0600-0859		11	7	11	15 W-H	76 W-H	1	0
				0900-1129	2	2	4	0	0
					1130-1329	0	2	2	0
						1330-1629	2	0	0
							1630-1829	1	1
								1830-2059	1
									2100-2359

TRIP ONE TO TRIP TWO
TOTAL FOUR-TRIP WEEKDAYS: 146

LEGEND
H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 5
FOUR-TRIP WEEKDAY TRANSITION MATRIX

November 26, 1969

-18-

TM-(L)-4119/003/00

TO TIME SLOT		0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
FROM TIME SLOT	0000-0559	0	0	0	0	0	0	0	0
	0600-0859		2	4	0	3	4	0	1
	0900-1129			1	5	3	1	0	0
	1130-1329				5	6	2	0	0
	1330-1629					9	12	4	0
	1630-1829						32 H-S	47 H-S H-R	1
	1830-2059							4	0
	2100-2359								0

TRIP TWO TO TRIP THREE
TOTAL FOUR-TRIP WEEKDAYS: 146

LEGEND
H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 6
FOUR-TRIP WEEKDAY TRANSITION MATRIX

November 26, 1969

-19-

TM-(L)-4119/003/00

TO TIME SLOT		0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
FROM TIME SLOT	0000-0559	0	0	0	0	0	0	0	0
	0600-0859		0	0	0	0	0	2	0
	0900-1129			0	0	0	4	0	1
	1130-1329				0	4	5	1	0
	1330-1629					6	11 W-H	3	1
	1630-1829						23 S-H	16 S-H	12
	1830-2059							28	27 R-H S-H
	2100-2359								2

TRIP THREE TO TRIP FOUR
TOTAL FOUR-TRIP WEEKDAYS: 146

LEGEND
H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 7
FOUR-TRIP WEEKDAY TRANSITION MATRIX

TABLE 5
THE TYPICAL FOUR-TRIP DAY (EVENING) PATTERN
(REPRESENTS 37% OF ALL FOUR-TRIP DAYS, 6.7% OF ALL COMPLETE CAR WEEKDAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME		MEAN ELAPSED TIME (MIN)	DISTANCE (MILES)		AVERAGE SPEED (MPH)		NUMBER OF STOPS (IDLES)		IDLE TIME (MIN)	
				MEAN	RANGE*		MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**		
1A	WORK	1	NF	0722	0642 - 0802	20.1	6.9	0.1 - 11.0	20.5	15.0 - 30.0	8.6	2.0 - 15.0	0.6	0.0 - 1.0
1B	OR:													
	WORK	1	NF	0715	0633 - 0757	8.8	3.5	0.1 - 7.0	24.2	10.0 - 40.0	4.9	2.0 - 8.0	0.4	0.0 - 1.0
	2	F				14.8	8.5	2.0 - 13.0	34.5	20.0 - 50.0	1.3	0.0 - 2.0	0.0	0.0 - 1.0
		3	NF			10.2	4.5	0.1 - 7.0	26.6	15.0 - 40.0	4.6	0.0 - 8.0	0.2	0.0 - 1.0
							16.5				10.8		0.6	
TRIPS 1A AND 1B OCCUR IN THE RATIO OF 2 TO 1 RESPECTIVELY														
2A	HOME	1	NF	1713	1638 - 1748	19.8	6.9	0.1 - 11.0	20.9	15.0 - 35.0	9.5	4.0 - 15.0	0.8	0.0 - 1.0
2B	OR:													
	HOME	1	NF	1701	1632 - 1730	10.5	4.5	0.1 - 7.0	25.7	10.0 - 40.0	7.0	4.0 - 11.0	0.2	0.0 - 1.0
	2	F				15.1	8.5	2.0 - 13.0	33.7	15.0 - 50.0	1.6	0.0 - 3.0	0.1	0.0 - 1.0
		3	NF			8.0	3.5	0.1 - 7.0	26.2	10.0 - 40.0	3.7	0.0 - 8.0	0.1	0.0 - 1.0
							33.5				12.3		0.4	
TRIPS 2A AND 2B OCCUR IN THE RATIO OF 2 TO 1 RESPECTIVELY														
3	SHOP OR RECREATION	1	NF	1822	1727 - 1917	9.2	3.4	0.1 - 6.0	22.2	15.0 - 35.0	5.0	3.0 - 7.0	0.3	0.0 - 1.0
A	HOME	1	NF	1945	1902 - 2021	9.5	3.5	0.1 - 6.0	22.0	15.0 - 35.0	3.8	0.0 - 7.0	0.3	0.0 - 1.0

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

Noon Patterns

Cell 24 in Figure 5 shows 11 cars transitioning from a trip in time slot two to a trip in time slot four. All of them transition from a first trip to work, three of them to a shopping trip, and eight to a business trip. Under the definition of trip purpose given to survey participants, any of these trips could be to lunch. In Figure 6, cell 44 shows five trip twos transitioning to trip threes in time slot four. All of these are return trips to work, two from shopping and three from business. Cell 45 shows six trip twos transitioning to trip threes between time slots four and five. Four of these are return trips to work, three from business and one from shopping.

Cell 46 of Figure 7 shows that five third trips in time slot four transition to a fourth trip in time slot six. Four of these are from work to home. In addition, cell 56 shows 11 third trips that transition to fourth trips between time slot five and six. Five of these are from work to home. These data indicate the structure of the typical Four-Trip (Noon) Pattern: trip one is to work, trip two to lunch, trip three back to work, and trip four home in the evening.

The noontime trips are both nonfreeway. The values in Table 6 are obtained by combining and weighting the computed values for the two principal purposes: business and shopping. The morning work trip and the evening return home trip have the same structure as in the other typical patterns and are weighted in the same way.

The minimum number of car-days that showed the Four-Trip Day (Noon) Pattern was nine. This number represents 6% of all four-trip days and 1.1% of all car-days in the sample.

TABLE 6
THE TYPICAL FOUR-TRIP DAY (NOON) PATTERN
(REPRESENTS 7% OF ALL FOUR-TRIP DAYS, 1.2% OF ALL CAR-DAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME		MEAN ELAPSED TIME (MIN)	DISTANCE (MILES)		AVERAGE SPEED (MPH)		NUMBER OF STOPS (IDLES)		IDLE TIME (MIN)	
				MEAN	RANGE*		MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**
1A	WORK	1	NF	0722	0642 - 0802	20.1	6.9	0.1 - 11.0	20.5	15.0 - 30.0	4.6	2.0 - 15.0	0.6	0.0 - 1.0
1B	OR: WORK	1	NF	0715	0633 - 1757	8.3	3.5	0.1 - 7.0	24.2	10.0 - 40.0	4.9	2.0 - 8.0	0.4	0.0 - 1.0
		2	F			14.8	8.5	2.0 - 13.0	24.5	20.0 - 50.0	1.3	0.0 - 2.0	0.0	0.0 - 1.0
		3	NF			10.2	4.5	0.1 - 7.0	26.6	15.0 - 40.0	4.6	0.0 - 8.0	0.2	0.0 - 1.0
						33.8	16.5				10.8		0.6	
TRIPS 1A AND 1B OCCUR IN THE RATIO OF 2 TO 1 RESPECTIVELY														
2	SHOP, BUSINESS (LUNCH)	1	NF	1220	1144 - 1256	10.0	3.7	0.1 - 6.0	22.2	15.0 - 40.0	4.9	0.0 - 9.0	0.8	0.0 - 1.0
3	WORK	1	NF	1224	1150 - 1258	6.0	2.6	0.1 - 5.0	25.9	15.0 - 40.0	3.8	0.0 - 6.0	0.0	0.0 - 1.0
4A	HOME	1	NF	1713	1638 - 1748	19.8	6.9	0.1 - 11.0	20.9	15.0 - 35.0	9.5	4.0 - 15.0	0.8	0.1 - 1.0
4B	OR: HOME	1	NF	1701	1632 - 1730	10.5	4.5	0.1 - 7.0	25.7	10.0 - 40.0	7.0	4.0 - 11.0	0.2	0.0 - 1.0
		2	F			15.1	8.5	2.0 - 13.0	33.7	15.0 - 50.0	1.6	0.0 - 3.0	0.1	0.0 - 1.0
		3	NF			8.0	3.5	0.1 - 7.0	26.2	10.0 - 40.0	3.7	0.0 - 8.0	0.1	0.0 - 1.0
						33.6	16.5				12.3		0.4	
TRIPS 4A AND 4B OCCUR IN THE RATIO OF 2 TO 1 RESPECTIVELY														

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

The Five-Trip Day

Figures 8 through 11 contain the trip-to-trip transition matrices for the five-trip day. As noted earlier, as the number of trips per day increases, the number of possible trip-to-trip combinations increases geometrically and the likelihood of detecting a typical pattern decreases. The matrices for the five-trip day require careful study of both time slot and purpose transitions to detect the typical pattern that is present.

Of the 53 transitions in cell 26 of Figure 8, 34 are from work trips in time slot two to home trips in time slot six. Six of the 16 transitions in the adjacent cell 25 have a similar purpose-to-purpose pattern. In Figure 9, 29 of the 52 transitions in cells 66 and 67 are from home to shopping or recreation. Of the 49 trips three to trip four transitions in cells 67 and 77 of Figure 10, 27 are between various combinations of shopping, school and recreation. Finally, in Figure 11, 42 of the 49 transitions in cells 67 and 77 are from shopping, school or recreation to home.

From these transitions we deduce the Five-Trip (Evening) Pattern. A first trip to work in time slot two, a return trip home in time slot six, a shopping, recreation or school trip in time slot six or seven followed by another in time slot seven, and finally a return home in time slot seven.

The minimum number of cars that followed this pattern in Chicago was 27 (using the number that transitioned from a third trip for shopping or recreation in time slot six or seven to a fourth trip for a similar purpose in the same time slots. This figure represents 22% of all the five-trip days and 3.4% of all the complete car-weekdays in the Chicago survey.

Table 7 contains the description of the trips that make up the Five-Trip Day.

November 26, 1969

-24-

TM-(L)-4119/003/00

TO TIME SLOT		0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
FROM TIME SLOT	0000-0559	3	8	1	1	4	0	0	0
	0600-0859		3	10	14	16 W-H W-B W-S	53 W-H W-S	1	0
				0900-1129	4	2	0	0	0
					1130-1329	1	2	1	0
						1330-1629	0	0	0
							1630-1829	0	0
								1830-2059	0
									2100-2359

TRIP ONE TO TRIP TWO
TOTAL FIVE-TRIP WEEKDAYS: 124

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 8
FIVE-TRIP WEEKDAY TRANSITION MATRIX

November 26, 1969

-25-

TM-(L)-4119/003/00

TO TIME SLOT		0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
FROM TIME SLOT	0000-0559	0	2	1	0	0	0	0	0
	0600-0859		1	1	1	1	6	1	0
				0900-1129	8	5	0	1	0
					1130-1329	8	4	6	0
						1330-1629	9	11	2
							1630-1829	27 H-S S-H	25 H-S
								1830-2059	0
									2100-2359

TRIP TWO TO TRIP THREE
TOTAL FIVE-TRIP WEEKDAYS: 124

LEGEND
H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 9
FIVE-TRIP WEEKDAY TRANSITION MATRIX

November 26, 1969

-26-

TM-(L)-4119/003/00

TO TIME SLOT		0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
FROM TIME SLOT	0000-0559	0	0	0	0	0	0	0	0
	0600-0859		0	1	0	0	0	2	0
			0900-1129	2	5	1	1	1	0
				1130-1329	4	6	3	1	0
					1330-1629	2	11	1	0
						1630-1829	21 S-S H-S	27 S-S H-S	3
							1830-2059	22 S-S	6
								2100-2359	4

TRIP THREE TO TRIP FOUR
TOTAL FIVE-TRIP WEEKDAYS: 124

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 10
FIVE-TRIP WEEKDAY TRANSITION MATRIX

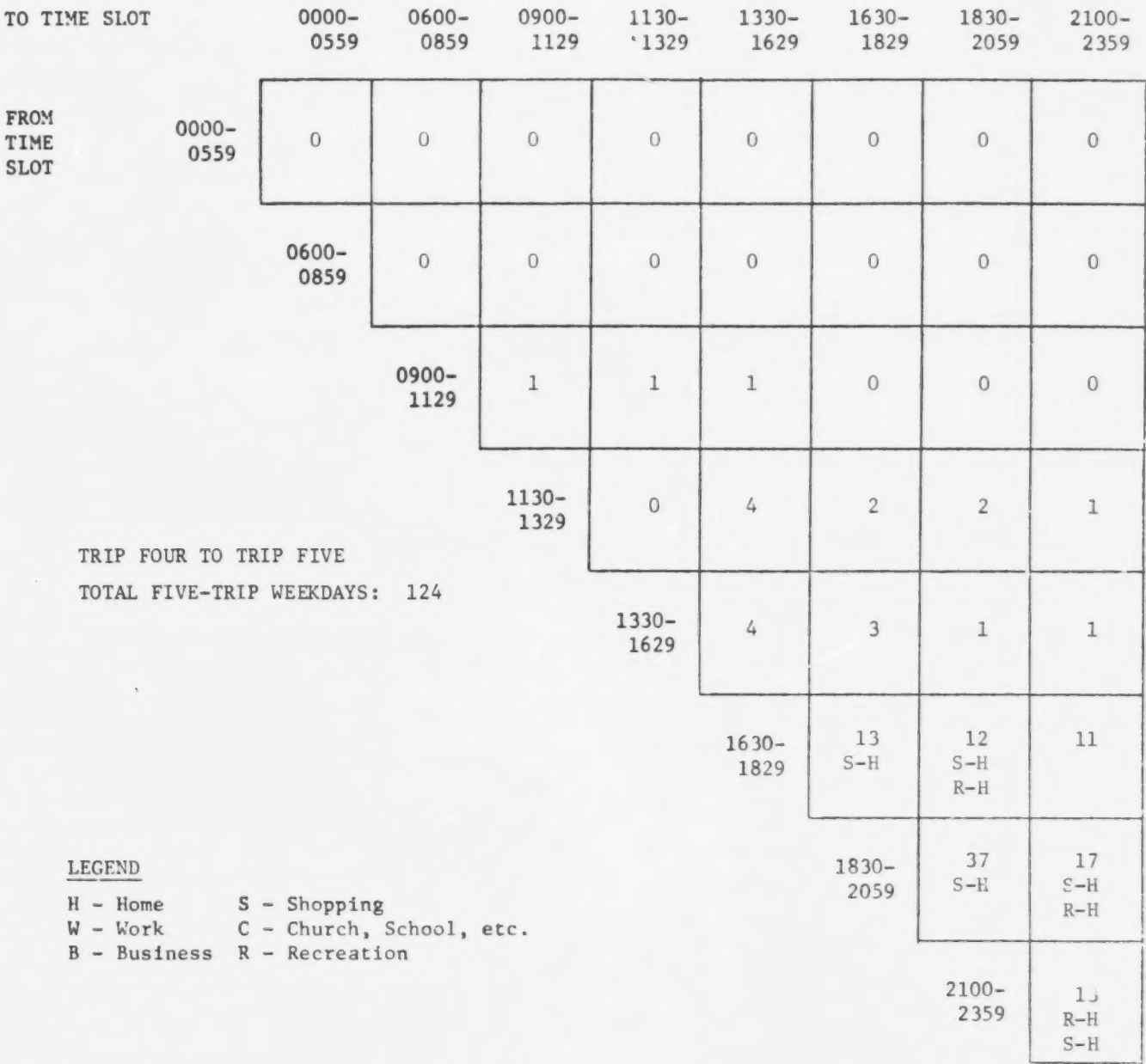


FIGURE 11
FIVE-TRIP WEEKDAY TRANSITION MATRIX

TABLE 7
THE TYPICAL FIVE-TRIP DAY PATTERNS
(REPRESENTS 19% OF ALL FIVE-TRIP DAYS, 3.0% OF ALL CAR DAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME		MEAN ELAPSED TIME (MIN)	DISTANCE (MILES)		AVERAGE SPEED (MPH)		NUMBER OF STOPS (IDLES)		IDLE TIME (MIN)	
				MEAN	RANGE*		MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**
1A	WORK	1	NF	0722	0642 - 0802	20.1	6.9	0.1 - 11.0	20.5	15.0 - 30.0	8.6	2.0 - 15.0	0.6	0.0 - 1.0
1B	OR: WORK	1	NF	0715	1633 - 0757	8.8	3.5	0.1 - 7.0	24.2	10.0 - 40.0	4.9	2.0 - 8.0	0.4	0.0 - 1.0
		2				14.8	8.5	2.0 - 13.0	34.5	20.0 - 50.0	1.3	0.0 - 2.0	0.0	0.0 - 1.0
		3				10.2	4.5	0.1 - 7.0	26.6	15.0 - 40.0	4.6	0.0 - 8.0	0.2	0.0 - 1.0
TRIPS 1A AND 1B OCCUR IN THE RATIO OF 2 TO 1 RESPECTIVELY						33.8	16.5			10.8		0.6		
2A	HOME	1	NF	1713	1633 - 1748	19.8	6.9	0.1 - 11.0	20.9	15.0 - 35.0	9.5	4.0 - 15.0	0.8	0.0 - 1.0
2B	OR: HOME	1	NF	1701	1632 - 1730	10.5	4.5	0.1 - 7.0	25.7	10.0 - 40.0	7.0	4.0 - 11.0	0.2	0.0 - 1.0
		2	F			15.1	8.5	2.0 - 13.0	33.7	15.0 - 50.0	1.6	0.0 - 3.0	0.1	0.0 - 1.0
		3	NF			8.0	3.5	0.1 - 7.0	26.2	10.0 - 40.0	3.7	0.0 - 8.0	0.1	0.0 - 1.0
TRIPS 2A AND 2B OCCUR IN THE RATIO OF 2 TO 1 RESPECTIVELY						33.6	16.5			12.3		0.4		
3	SHOP OR RECREATION	1	NF	1822	1727 - 1917	9.2	3.4	0.1 - 6.0	22.2	15.0 - 35.0	5.0	3.0 - 7.0	0.3	0.0 - 1.0
4	SHOP OR RECREATION	1	NF	1938	1859 - 2018	8.1	3.0	0.1 - 5.0	22.3	15.0 - 35.0	4.3	0.0 - 8.0	0.2	0.0 - 1.0
5	HOME	1	NF	1945	1902 - 2021	9.5	3.5	9.1 - 6.0	22.0	15.0 - 35.0	3.8	0.0 - 7.0	0.3	0.0 - 1.0

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

GENERAL RESULTS

This section contains a discussion of additional results of the study including a description of the sample, an analysis of daily variations in the data, and an analysis of the individual trip and segment variables as they are affected by such factors as time of day, trip purpose, and type of route used.

The Chicago Sample

During the Chicago survey, SDC installed Tachographs in 199 automobiles. For various reasons, described more fully in the Appendix to this report, data from 28 of these installations were totally unusable. The results of this study, then, are based on data from 171 automobiles driven in the Chicago metropolitan area during the period April 21, 1969 to May 29, 1969.

A total of 1197 complete car-days are included in the sample. During these days, participating drivers completed 5938 trips, 4230 on weekdays and 1708 on weekend days. The average trip generation rate was 5.0 trips per day. Participants drove in excess of 40,000 miles during the survey, an average of 31.0 miles per day. Time spent driving by the average participant amounted to one hour and 30 minutes per day.

Sample Biases

As discussed in Volume 0, Part II of this report, the method used in selecting survey participants biased the sample toward working members of the overall population. In view of this bias, SDC expected that work-related trips would constitute a major component of the resultant typical trip patterns described in the previous section. There is no doubt in our minds that such work-related utilization pattern in the Chicago urban area. The sample was made up of utilization pattern in the Cincinnati urban area. The sample was made up of participants from all levels of the corporate structure within the participating firms, and the firms represented a reasonable cross-section, in terms of size, of all firms in the area. The results of the survey, therefore, represent a good cross-section of driving behavior within the industrial and commercial sector of the community.

A second bias which has been suggested is that the cars which participated in the survey, being primarily used for transportation to and from work, were not the types of cars people would use for extended trips on weekends or holidays. This would, according to those supporting this theory, explain the somewhat low incidence of long trips and the increased number of zero-trip days on weekends. This argument is bolstered by the fact that SDC chose to exclude station wagons, campers, and pickup trucks from the survey because of certain difficulties inherent in the installation of Tachographs in these vehicles. In the case of Chicago, this argument is somewhat strengthened by the fact that the trip generation rate of all cars was practically the same on both weekdays and weekend days (5.0 trips per weekday, 4.9 trips per weekend day), the trip generation rates for days actually driven (i.e., including zero-trip days) was higher for weekend days than for weekdays (6.1 trips per day vs. 5.0 trips per day).

The logistics involved in installing Tachographs in the survey cars required a correction in the survey results to compensate for inconsistencies in the data. The instruments were installed during the morning and afternoon of the first survey day for each car. They were removed during the morning of the eighth day. As a result, the data collected during each car's week represented eight calendar days, but the first and eighth days each contained only about a half-day's worth of data. In order to remove this "half-day" bias which would certainly affect the daily pattern of automobile usage reflected in the results of the survey, data from the last half of the first day and from the first half of the eighth day were combined during the data reduction process. In no case was there an overlap of trips on the two combined days that would cause the loss of a trip in the final results. In Chicago there were also no cases in which data from one of the two days was unusable for one reason or another (failure of the Tachograph, errors in the recorded data, etc.).

Data Collected

The Tachograph instrument provided data indicating the day of the survey, trip and trip segment¹ start times and complete times, trip and segment distance traveled, length of periods of idling time in excess of 40 seconds, number of momentary stops, and type of road (freeway, nonfreeway) traveled for each segment. Information contained in the log book kept by the driver indicated the date, the purpose of each trip, geographic zone within which each trip started, type of location from which each trip started, road conditions, driver sex and age, whether the car was parked indoors or out at the end of each trip, and the fuel gauge reading at the start of each day. To these data we added various identifying and categorizing variables during the data reduction process so that the final record on each trip contains at least 54 separate data items.

Daily Patterns

Two classifications of the survey data were made in the analysis. First, data were segregated into two groups by weekday and weekend day. The latter included only Saturday and Sunday. Second, the data were segregated into seven groups by day of the week. The latter was done at the request of CRC² to enable an examination of any daily variation that may occur.

The data base for the Chicago survey contains 804 active car-weekdays and 278 active car-weekend days. To these sums must be added zero-trip days that occurred but are not contained in the data base: 51 car-weekdays and 64 car-weekend days. The resulting totals are 855 car-weekdays and 342 car-weekend days. Table 8 shows the daily breakdown of the sample into active and inactive car days.

¹ A trip segment is defined as that portion of a trip driven over a single type of road, either freeway or nonfreeway.

² CRC-APRAC Project Groups CAPE-5 and CAPE-10.

TABLE 8
DAILY SAMPLE SIZE IN CAR-DAYS

DAY	NUMBER OF CAR-DAYS IN SAMPLE		
	ACTIVE	INACTIVE (O-TRIP)	TOTAL
MONDAY	158	13	171
TUESDAY	157	14	171
WEDNESDAY	160	11	171
THURSDAY	164	7	171
FRIDAY	165	6	171
SATURDAY	146	25	171
SUNDAY	132	39	171

During the survey period, participants drove 5938 valid trips. These were divided into 4230 weekday trips and 1708 weekend trips. Tables 9 and 10 show the daily distribution by time slot of these trips as well as the weekday and weekend total distributions. Figure 12 presents a more detailed time distribution of weekday trip start times by 15-minute intervals. Figure 13 presents similar data for weekend trip start times.

Trip generation rates for active weekdays are 5.04 trips driven per day (i.e., including only those days on which trips were actually taken) and 4.95 trips per day for all days (i.e., including zero-trip days). On weekends, these rates are 6.14 and 4.91 trips per day respectively. The larger difference between the last two numbers reflects the greater likelihood of a zero-trip day on a Saturday or Sunday.

An analytical tool that assisted greatly in determining trip pattern relationships is the trip-to-trip transition matrix. It is a tableau showing the incidence of various trip-related dependencies between successive trips. In order to examine weekday-weekend and daily variations, summary two-step,

TABLE 9

TIME DISTRIBUTION OF WEEKDAY
TRIPS BY DAY AND TIME SLOT

DAY	TIME SLOT								DAILY TOTAL
	0000- 0559	0600- 0859	0900- 1129	1130- 1329	1330- 1629	1630- 1829	1830- 2059	2100- 2359	
MONDAY	24	150	65	59	100	190	120	50	758
TUESDAY	18	164	58	68	97	197	137	70	809
WEDNESDAY	32	142	54	55	81	209	161	65	799
THURSDAY	36	159	53	90	115	235	182	84	954
FRIDAY	29	158	69	84	116	218	159	77	910
WEEKDAY TOTAL	139	773	299	356	509	1049	759	346	4230

TABLE 10

TIME DISTRIBUTION OF WEEKEND
TRIPS BY DAY AND TIME SLOT

DAY	TIME SLOT						DAILY TOTAL
	0000- 0829	0830- 1059	1100- 1259	1300- 1759	1800- 2059	2100- 2359	
SATURDAY	99	151	183	371	126	61	991
SUNDAY	75	105	136	241	112	48	717
WEEKEND TOTAL	174	256	319	612	238	109	1708

November 26, 1969

-34-

TM-(L)-4119/003/00



FIGURE 12
DISTRIBUTION OF WEEKDAY TRIP START TIMES

November 26, 1969

-35-

TM-(L)-4119/003/00



FIGURE 13
DISTRIBUTION OF WEEKEND TRIP START TIMES

trip-to-trip transition matrices were assembled for all trips. Figures 14 and 15 are simplified versions of these matrices. The weekday matrix, of which only the upper right-hand triangle is shown, is divided into nine rows and eight columns. Rows two through nine and columns one through eight correspond to the eight weekday time slots. The first row is called the zero row and corresponds to any time slot on the previous day. A trip in the j^{th} time slot of any weekday that was preceded by a trip in the i^{th} time slot is tabulated in cell ij where i denotes the row and j denotes the column of the transition matrix. If a previous trip took place on the preceding day, the trip is tabulated in zero row in the column appropriate to its own time slot. In the original matrix, the purpose-to-purpose transition is also shown. We have simplified the matrix in Figure 14 by showing only the modal or typical purpose pattern(s) in cells that have high frequency counts. Figure 15 shows the matrix for weekend trips. This matrix is a seven-by-six matrix due to the reduced number of time slots on weekdays. The literal coded entries in certain cells indicate purpose-to-purpose transitions that clearly stand out as typifying the particular time slot transition.

A final analytical tool used to evaluate daily variation in trip patterns is a two-way contingency table showing the incidence of particular trip purpose and trip segment string combinations in each time slot. These tables were prepared for weekday, weekend, and daily breakdowns of the data. Chi-square tableaux were prepared for each of these tables to see which purpose stood out as typical for each time slot. In these tableaux, an "expected" frequency count is compiled for each cell by reallocating each column total over the cells in that column in proportion to the row totals. The assumption behind this computation is that row and column effects do not interact to affect the cell totals. In the case at hand, it is clear that these effects do interact (e.g., there is more likelihood of a go-to-work trip being taken in time slot two than in time slot eight). Because there is interaction, the differences between the actual cell counts and the "expected" cell counts obtained by

November 26, 1969

-37-

TM-(L)-4119/003/00

TO TIME SLOT		0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
FROM TIME SLOT	PREVIOUS DAY	95	605 H-W H-B H-S	52	18	11	15	6	2
	0000-0559	44	51	12	3	23	4	1	0
	0600-0859		117	105	76	98	352 W-H W-S	16	4
	0900-1129			130	107	37	17	4	2
	1130-1329				152	127	58	9	7
	1330-1629					213 S-H B-B H-S B-H	192 H-S S-H	39	8
	1630-1829						411 S-H H-S S-S H-R	337 H-S S-H S-S H-R	65
	1830-2059							347 S-H S-S R-H H-S	159
TOTAL WEEKDAY TRIPS: 4230								2100-2359	99

LEGEND

H - Home S - Shopping
 W - Work C - Church, School, etc.
 B - Business R - Recreation

FIGURE 14

TWO-STEP TRIP-TO-TRIP
 TRANSITION MATRIX, ALL WEEKDAY TRIPS

November 26, 1969

-38-

TM-(L)-4119/003/00

TO TIME SLOT		0000- 0829	0830- 1059	1100- 1259	1300- 1759	1800- 2059	2100- 2359
FROM TIME SLOT	PREVIOUS DAY	112 H-W H-S R-H	86	46	30	3	1
	0000- 0829	62	51	27	26	1	0
	0830- 1059		119 S-H S-S	91	28	8	0
				155 S-H H-S S-S	130 H-S S-H	7	2
					398 S-H S-S R-R H-S	112 R-H	23
						108 S-H	50
TOTAL WEEKEND TRIPS: 1708							2100- 2359 32

LEGEND

H - Home S - Shopping
W - Work C - Church, School, etc.
B - Business R - Recreation

FIGURE 15
TWO-STEP TRIP-TO-TRIP
TRANSITION MATRIX, ALL WEEKEND TRIPS

computation indicate which purpose or trip segment string (row) is typical of the time slot. Tables 11 and 12 show the purpose-time slot contingency tables for weekday and weekend trips. "Expected" frequency counts for each cell are shown in italics below the actual frequency counts. Within the frequency table, the characteristic purpose(s) for each time slot is indicated by underlining the cell count we consider typical.

An analysis of the individual weekday tables compared to the total weekday table in terms of percentage was carried out using the chi-square test. The purpose of the analysis was to detect any significant daily variation in the time slot distribution of trips or in the purpose distribution. The significance level of 0.95 was used. Results of the test showed that the seven weekdays constituted homogeneous samples with respect to both time slot and purpose distributions.

The time slot distribution of trip segment string is shown in Table 13 for weekday trips and in Table 14 for weekend trips. "Expected" frequencies are again shown in italics. The weekday figures indicate an interesting concentration of freeway utilization in the morning hours when compared to the "expectations." The disparity between actual and "expected" frequencies does not recur to the same extent during the evening rush hour even though there are similarly large numbers of trips that use freeways. No doubt this is indicative of the high likelihood that a trip to or from work will use freeways for part of its completion. During the morning hours, especially in time slot two, trips to work constitute such a major portion of all traffic that anything characteristic of them will dominate the statistics of the period. On weekends the use of freeways is diminished both in frequency and in comparison between actual and "expected" frequency in all but the first time slot.

TABLE 11
 ACTUAL AND "EXPECTED" FREQUENCIES OF TRIP PURPOSE
 BY TIME SLOT FOR WEEKDAY TRIPS
 CHARACTERISTIC TIME SLOT PURPOSES UNDERLINED

TIME SLOT PURPOSE	I 0000- 0559	II 0600- 0859	III 0900- 1129	IV 1130- 1329	V 1330- 1629	VI 1630- 1829	VII 1830- 2059	VIII 2100- 2359	TOTALS
GO HOME	20 45	41 250	47 97	34 115	178 165	513 339	301 245	234 112	1368
GO TO WORK	59 28	563 158	41 61	79 73	51 104	51 214	12 155	7 70	863
BUSINESS	37 22	86 125	136 48	134 57	133 82	73 169	60 122	23 56	682
SHOP	16 29	66 163	53 63	88 75	110 107	287 221	239 160	31 73	890
SCHOOL	1 2	8 11	7 4	2 5	6 7	20 15	15 11	1 5	60
RECREATION	6 12	9 67	15 26	19 31	31 44	105 91	132 66	50 30	367
TOTALS	139	773	299	356	509	1049	759	346	4230

ACTUAL FREQUENCY
 "EXPECTED" FREQUENCY (IN ITALICS)

TABLE 12
 ACTUAL AND "EXPECTED" FREQUENCIES OF TRIP PURPOSE
 BY TIME SLOT FOR WEEKEND TRIPS
 CHARACTERISTIC TIME SLOT PURPOSES UNDERLINED

TIME SLOT PURPOSE	I 0000- 0829	II 0830- 1059	III 1100- 1259	IV 1300- 1759	V 1800- 2059	IV 2100- 2359	TOTALS
GO HOME	46 <u>60</u>	67 <u>89</u>	109 <u>110</u>	203 <u>212</u>	98 <u>82</u>	68 <u>38</u>	591
GO TO WORK	27 <u>7</u>	13 <u>10</u>	12 <u>12</u>	7 <u>23</u>	3 <u>9</u>	3 <u>4</u>	65
BUSINESS	19 <u>10</u>	17 <u>14</u>	17 <u>18</u>	34 <u>34</u>	6 <u>14</u>	3 <u>6</u>	96
SHOPPING	41 <u>56</u>	108 <u>82</u>	122 <u>103</u>	206 <u>197</u>	60 <u>76</u>	11 <u>35</u>	548
SCHOOL	16 <u>6</u>	21 <u>9</u>	10 <u>11</u>	9 <u>22</u>	4 <u>9</u>	1 <u>4</u>	61
RECREATION	25 <u>35</u>	30 <u>52</u>	49 <u>65</u>	153 <u>124</u>	67 <u>48</u>	23 <u>22</u>	347
TOTALS	174	256	319	612	238	109	1708

ACTUAL FREQUENCY
 "EXPECTED" FREQUENCY

TABLE 13

ACTUAL AND "EXPECTED" FREQUENCIES OF TRIP
SEGMENT STRING BY TIME SLOT FOR WEEKDAYS

TRIP SEGMENT STRING	TIME SLOT								TOTALS
	0000- 0559	0600- 0859	0900- 1129	1130- 1329	1330- 1629	1630- 1829	1830- 2059	2100- 2359	
N	107 177	504 618	232 239	306 285	429 407	826 839	682 607	297 277	3383
NFN	31 26	254 145	63 56	45 67	74 96	207 197	73 143	48 65	795
NFNFN	1 2	14 7	3 3	4 3	6 5	9 10	2 7	1 3	40
OTHER	0 0	1 2	1 1	1 1	0 2	7 3	2 2	0 1	12
TOTALS	139	773	299	356	509	1049	759	346	4230

ACTUAL FREQUENCY
"EXPECTED" FREQUENCY

N = NONFREEWAY SEGMENT
F = FREEWAY SEGMENT

TABLE 14

ACTUAL AND "EXPECTED" FREQUENCIES OF TRIP
SEGMENT STRING BY TIME SLOT FOR WEEKENDS

TRIP SEGMENT STRING	TIME SLOT						TOTALS
	0000- 0829	0830- 1059	1100- 1259	1300- 1359	1800- 2059	2100- 2359	
N	146 152	229 223	282 274	542 534	205 208	86 95	1490
NFN	25 20	24 30	34 36	61 70	32 27	19 12	195
NFNFN	1 2	1 2	2 3	8 6	1 2	1 1	16
OTHER	0 1	2 1	1 1	1 2	0 1	3 1	7
TOTALS	174	256	319	612	238	109	1709

ACTUAL FREQUENCY
"EXPECTED" FREQUENCY

N = NONFREEWAY SEGMENT
F = FREEWAY SEGMENT

Trip Descriptors

The discussion of general results so far has dealt with the incidence of variables that can only be counted. These variables essentially define cases under which we wish to examine the behavior of such trip-descriptive variables as distance, elapsed time, velocity, number of stops with engine on and off, and idling time. The present section is devoted to a detailed examination of these variables.

Trip and Segment Distance

The average distance per trip driven during the survey was 6.81 miles. This number is deceptive, however. The distribution of trip distances understandably shows a wide range as is indicated in Figure 16, Distribution of Weekday Trip Distance, and in Figure 17, Distribution of Weekend Trip Distance. Of more particular interest is the time distribution of distance with respect to trip segment string. Tables 15 and 16 show the time slot distribution of number of trips by trip segment string for weekday and weekend respectively along with the average trip distance for each type of trip during the time slot. Tables 17 and 18 show the distribution of segment distance by time slot for nonfreeway and freeway segments associated with freeway trips on weekdays and weekend days.

The data in Figures 16 and 17 are arbitrarily cut off above 28 miles. Nevertheless, these figures account for 97.4% of all weekday trips and 97.1% of all weekend trips.

Trip and Segment Velocity

The distribution of trip velocity, as shown in Figure 18 for weekdays and in Figure 19 for weekends, is unimodal in both cases (i.e., single peaked). The weekend distribution is, however, slightly more spread as indicated by its larger standard deviation, 10.7 versus 10.3 for weekday trips.

November 26, 1969

-44-

TM-(L)-4119/003/00



FIGURE 16
DISTRIBUTION OF TRIP DISTANCE, WEEKDAY TRIPS

November 26, 1969

-45-

TM-(L)-4119/003/00



FIGURE 17
DISTRIBUTION OF TRIP DISTANCE, WEEKEND TRIPS

November 26, 1969

-46-

TM-(L)-4119/003/00

TABLE 15

DISTRIBUTION OF WEEKDAY TRIPS IN CHICAGO SURVEY BY TRIP
SEGMENT STRING SHOWING AVERAGE DISTANCE PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000- 0559	0600- 0859	0900- 1129	1130- 1329	1330- 1629	1630- 1829	1830- 2059	2100- 2359	
N: NUMBER OF CASES MEAN DISTANCE (MI.)	107 6.5	504 6.4	232 4.0	306 3.5	429 4.6	826 4.4	682 3.3	297 4.3	3383 4.5
NFN: NUMBER OF CASES MEAN DISTANCE	31 16.8	254 17.1	63 16.9	45 17.2	74 17.9	207 17.4	73 15.9	48 19.8	795 17.3
NFNFN: NUMBER OF CASES MEAN DISTANCE	1 44.1	14 20.8	3 75.3	4 37.2	6 14.9	9 25.3	2 23.8	1 26.6	40 27.5
OTHER: NUMBER OF CASES MEAN DISTANCE	0 0	1 7.7	1 1.4	1 172.8	0 0	7 6.1	2 1.0	0 0	12 18.9
TOTAL: NUMBER OF CASES MEAN DISTANCE	139 9.1	773 10.2	299 7.4	356 6.1	509 6.7	1049 7.2	759 4.6	346 6.5	4230 7.1

TABLE 16

DISTRIBUTION OF WEEKEND TRIPS IN CHICAGO SURVEY BY TRIP
SEGMENT STRING SHOWING AVERAGE DISTANCE PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000- 0829	0830- 1059	1100- 1259	1300- 1759	1800- 2059	2100- 2359	
N: NUMBER OF CASES MEAN DISTANCE (MI.)	146 5.2	229 2.7	282 3.2	542 3.8	205 4.4	86 3.8	1490 3.7
NFN: NUMBER OF CASES MEAN DISTANCE	25 17.4	24 20.6	34 14.8	61 27.6	32 15.0	19 23.2	195 20.7
NFNFN: NUMBER OF CASES MEAN DISTANCE	3 22.2	1 114.2	2 22.3	8 56.6	1 17.9	1 17.7	16 44.8
OTHER: NUMBER OF CASES MEAN DISTANCE	0 0	2 1.5	1 126.3	1 0.3	0 0	3 13.3	7 24.2
TOTAL: NUMBER OF CASES MEAN DISTANCE	174 7.3	256 4.8	319 4.9	612 6.9	238 5.9	109 7.6	1708 6.1

TABLE 17
AVERAGE DISTANCE FOR SEGMENTS OF WEEKDAY
FREEWAY TRIPS BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT								TOTAL
	0000- 0559	0600- 0859	0900- 1129	1130- 1329	1330- 1629	1630- 1829	1830- 2059	2100- 2359	
NONFREEWAY ¹									
NUMBER OF CASES	74	562	132	103	182	440	159	93	1745
AVERAGE DISTANCE	3.9	4.0	3.7	3.4	3.8	3.9	3.7	4.5	3.9
FREEWAY									
NUMBER OF CASES	35	284	66	53	87	237	80	48	890
AVERAGE DISTANCE	9.4	8.5	11.8	12.4	9.8	9.1	8.3	11.3	9.4
TOTAL									
NUMBER OF CASES	109	846	198	156	269	677	239	141	2635
AVERAGE DISTANCE	5.7	5.5	6.4	6.5	5.7	5.7	5.2	6.8	5.8

¹ EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

TABLE 18
AVERAGE DISTANCE FOR SEGMENTS OF WEEKEND FREEWAY TRIPS
IN CHICAGO SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT						TOTAL
	0000- 0829	0830- 1059	1100- 1259	1300- 1759	1800- 2059	2100- 2359	
NONFREEWAY ¹							
NUMBER OF CASES	59	47	82	155	73	39	455
AVERAGE DISTANCE	3.6	4.6	3.9	5.6	3.8	4.1	4.5
FREEWAY							
NUMBER OF CASES	32	26	40	81	34	23	236
AVERAGE DISTANCE	9.2	13.3	9.0	18.7	8.0	12.4	13.0
TOTAL							
NUMBER OF CASES	91	73	122	236	107	62	691
AVERAGE DISTANCE	5.6	7.7	5.6	10.1	5.1	7.2	7.4

¹ EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)



FIGURE 18
DISTRIBUTION OF AVERAGE SPEED, WEEKDAY TRIPS



FIGURE 19
DISTRIBUTION OF AVERAGE SPEED, WEEKEND TRIPS

Again, the time and trip segment string distribution points out greater differences. Tables 19 and 20 are analogous to the previous tabular presentation on trip distance. One notices increased average velocities on all freeway-associated trips as compared to the nonfreeway trips, but the degree of increase varies with time slot.

Tables 21 and 22 provide average velocity information on freeway and freeway segments associated with freeway trips by time slot for weekdays and weekends.

Trip and Segment Elapsed Time

The distributions of elapsed time for weekday and weekend trips are shown in Figures 20 and 21 respectively. The mean for weekday trips is 17.9 minutes, for weekend trips it is 13.9 minutes. The weekday distribution indicates that 90% of all trips on these days are completed within 44 minutes. On weekends, this figure drops to 32 minutes.

Tables 23 and 24 show the mean elapsed time by time slot and trip segment string. The dependency of elapsed time on the complexity of the trip segment structure stands out clearly. Tables 25 and 26 present mean segment elapsed time for trips involving the use of freeways on weekdays and weekend days. The large number of short trip times is obviously related to the similar prevalence of short trip distances discussed previously.

Trip and Segment Idling

The present survey measures idling time in terms of two parameters: the number of stops with engine running per trip or segment and the actual idling time accumulated during periods of idling in excess of about 40 seconds. The mean number of stops per trip by time slot and trip segment string is shown in Tables 27 and 28 for weekday and weekend trips. Tables 29 and 30 show the mean number of stops for trip segments of freeway trips on weekdays and weekends.

November 26, 1969

-52-

TM-(L)-4119/003/00

TABLE 19

DISTRIBUTION OF WEEKDAY TRIPS IN CHICAGO SURVEY BY TRIP
SEGMENT STRING SHOWING AVERAGE SPEED IN MILES PER HOUR PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000- 0559	0600- 0859	0900- 1129	1130- 1329	1330- 1629	1630- 1829	1830- 2059	2100- 2359	
N: NUMBER OF CASES AVERAGE SPEED (MPH)	107 24.7	504 20.0	232 22.5	306 22.6	429 18.7	826 21.3	682 22.0	297 19.9	3383 21.1
NFN: NUMBER OF CASES AVERAGE SPEED	31 31.3	254 29.3	63 31.1	45 32.8	74 30.6	207 28.9	73 31.9	48 31.9	795 30.1
NFNFN: NUMBER OF CASES AVERAGE SPEED	1 33.7	14 30.9	3 36.9	4 36.3	6 20.7	9 24.4	2 31.3	1 23.0	40 28.8
OTHER: NUMBER OF CASES AVERAGE SPEED	0 0	1 25.3	1 5.0	1 64.3	0 0	7 20.7	2 70.9	0 0	12 31.8
TOTAL: NUMBER OF CASES AVERAGE SPEED	139 26.2	773 23.3	299 24.4	356 24.2	509 20.5	1049 22.3	759 23.1	346 21.6	4230 22.9

TABLE 20

DISTRIBUTION OF WEEKEND TRIPS IN CHICAGO SURVEY BY TRIP
SEGMENT STRING SHOWING AVERAGE SPEED IN MILES PER HOUR PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000- 0829	0830- 1059	1100- 1259	1330- 1759	1800- 2059	2100- 2359	
N: NUMBER OF CASES AVERAGE SPEED (MPH)	146 21.9	229 20.4	282 23.6	342 19.7	205 23.1	86 10.1	1490 21.2
NFN: NUMBER OF CASES AVERAGE SPEED	25 37.9	24 36.3	34 36.5	61 34.7	32 32.5	19 35.4	195 35.3
NFNFN: NUMBER OF CASES AVERAGE SPEED	3 34.8	1 50.8	2 34.7	8 34.6	1 13.5	1 28.8	16 34.0
OTHER: NUMBER OF CASES AVERAGE SPEED	0 0	2 31.3	1 52.8	1 11.5	0 0	3 28.7	7 30.4
TOTAL: NUMBER OF CASES AVERAGE SPEED	174 24.4	256 22.1	319 25.1	612 21.4	238 24.3	109 22.3	1708 23.0

TABLE 21
AVERAGE SPEED FOR SEGMENTS OF WEEKDAY FREEWAY
TRIPS IN CHICAGO SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT								TOTAL
	0000- 0559	0600- 0859	0900- 1129	1130- 1329	1330- 1629	1630- 1829	1830- 2059	2100- 2359	
NONFREEWAY ¹									
NUMBER OF CASES	74	562	132	103	182	440	159	93	1745
AVERAGE SPEED	28.4	25.5	26.7	30.8	23.8	25.2	27.6	28.5	26.1
FREEWAY									
NUMBER OF CASES	35	284	66	53	87	237	80	48	890
AVERAGE SPEED	36.2	35.0	39.2	38.9	37.4	34.7	40.1	38.2	36.4
TOTAL									
NUMBER OF CASES	109	846	198	156	269	677	239	141	2635
AVERAGE SPEED	30.9	28.7	30.9	33.6	28.2	28.5	31.8	31.8	29.6

¹ EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIP WITH N-TRIP SEGMENT SEQUENCE)

TABLE 22
AVERAGE SPEEDS FOR SEGMENTS OF WEEKEND FREEWAY
TRIPS IN CHICAGO SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT					TOTAL
	0000- 0829	0830- 1059	1100- 1259	1300- 1759	1800- 2059	2100- 2359
NONFREEWAY¹						
NUMBER OF CASES	59	47	82	155	73	39
AVERAGE SPEED	31.2	30.1	29.7	28.7	29.3	27.7
						455 29.4
FREEWAY						
NUMBER OF CASES	32	26	40	81	34	23
AVERAGE SPEED	43.4	47.3	44.3	41.3	37.3	39.3
						236 42.0
TOTAL						
NUMBER OF CASES	91	73	122	236	107	62
AVERAGE SPEED	35.5	36.2	34.5	33.0	31.8	32.0
						691 33.7

¹ EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

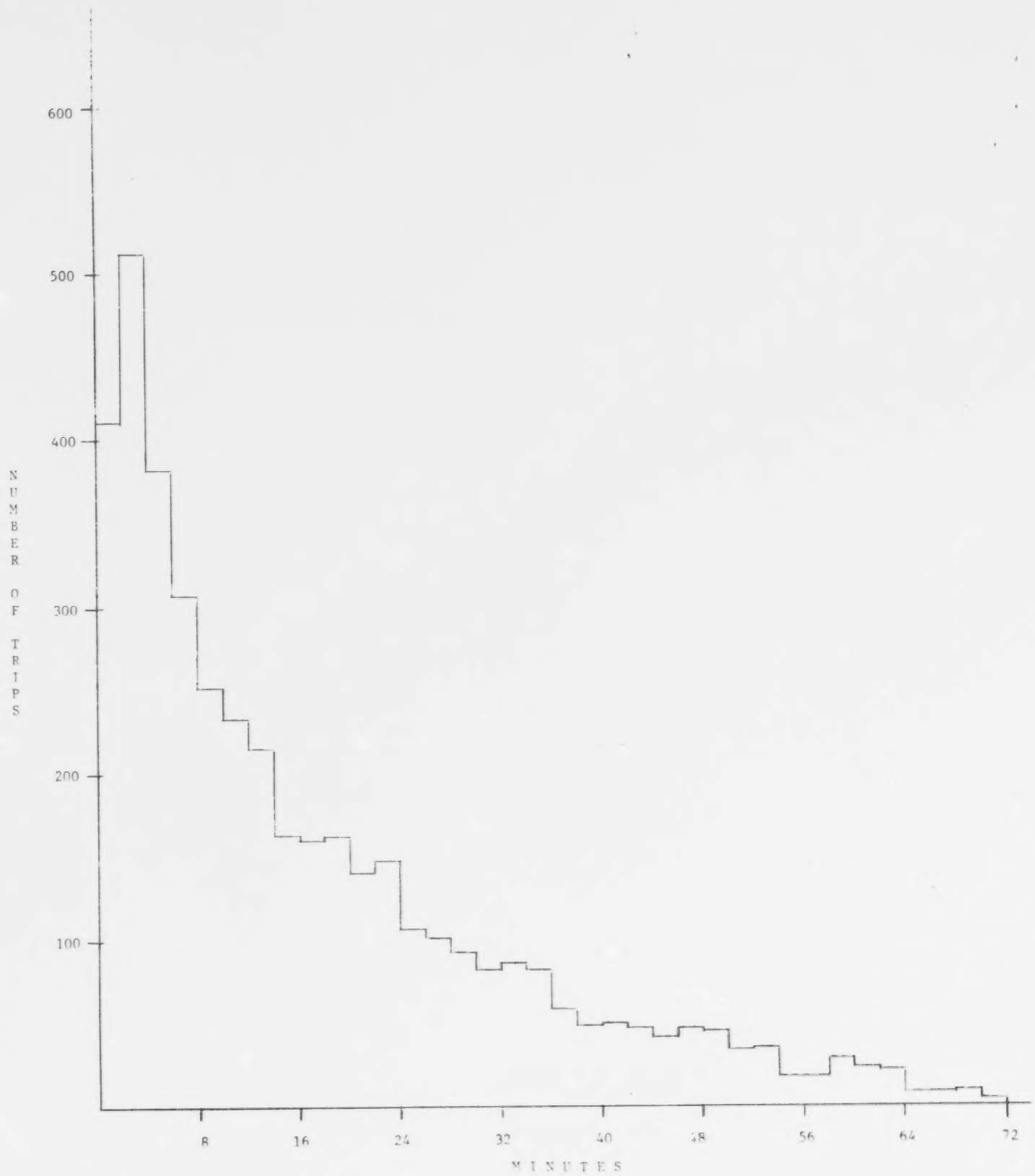


FIGURE 20
DISTRIBUTION OF TRIP TIME, WEEKDAY TRIPS

November 26, 1969

-56-

TM-(L)-4119/003/00

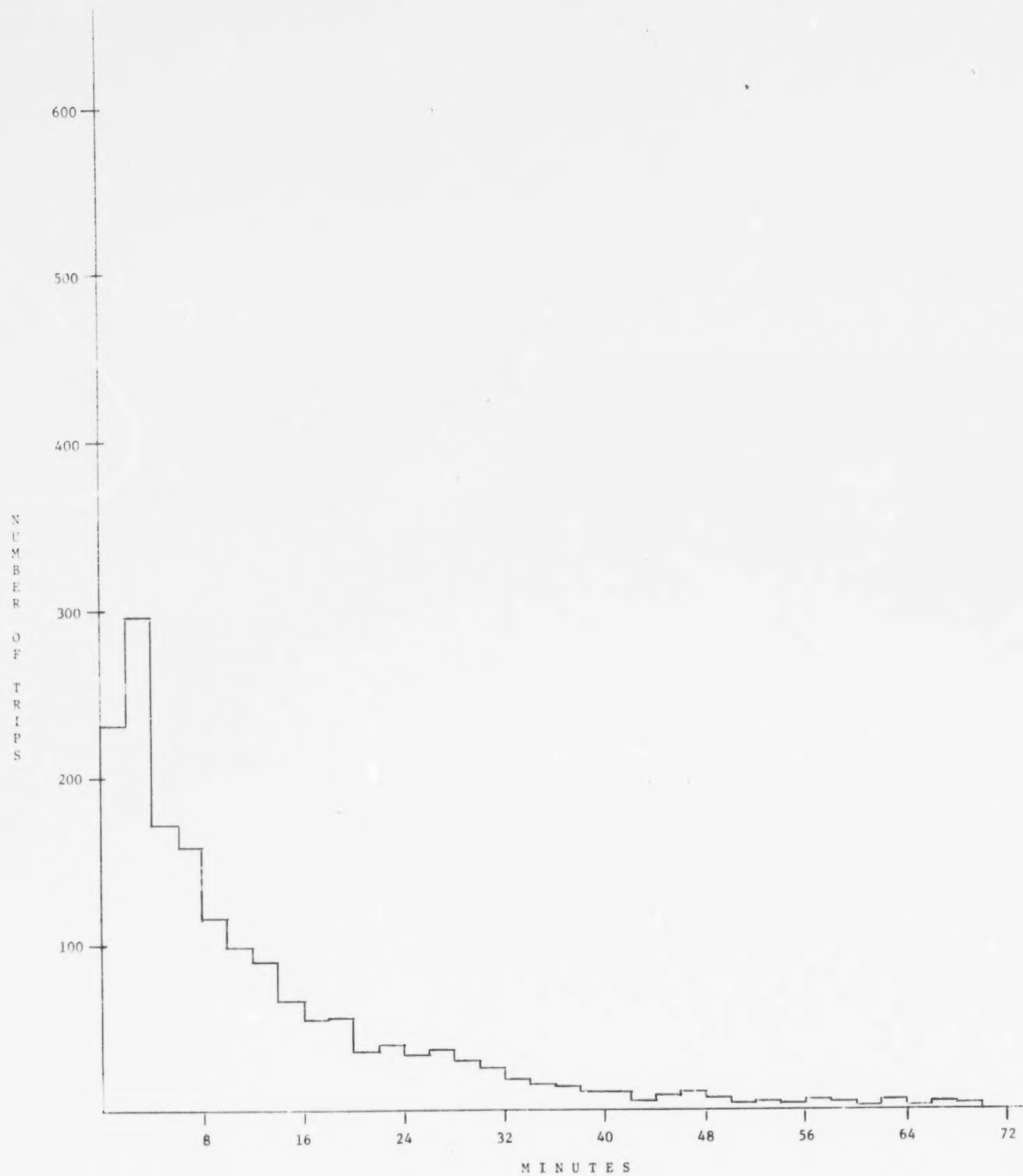


FIGURE 21
DISTRIBUTION OF TRIP TIME, WEEKEND TRIPS

TABLE 23

DISTRIBUTION OF WEEKDAY TRIPS IN THE CHICAGO SURVEY BY TRIP SEGMENT
STRING SHOWING AVERAGE TRIP ELAPSED TIME IN MINUTES PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000- 0559	0600- 0859	0900- 1129	1130- 1329	1330- 1629	1630- 1829	1830- 2059	2100- 2359	
N: NUMBER OF CASES ELAPSED TIME (MIN)	107 17.3	504 19.2	232 12.6	306 10.8	429 14.7	826 13.8	682 9.4	297 12.8	3383 13.5
NFN: NUMBER OF CASES ELAPSED TIME	31 33.2	254 35.2	63 32.1	45 28.3	74 34.6	207 36.5	73 29.9	48 37.2	795 34.4
NFNFN: NUMBER OF CASES ELAPSED TIME	1 80.0	14 42.3	3 102.7	4 59.5	6 43.1	9 60.9	2 44.7	1 69.5	40 54.0
OTHER: NUMBER OF CASES ELAPSED TIME	0 0	1 18.3	1 16.9	1 161.3	0 0	7 17.8	2 0.9	0 0	12 26.9
TOTAL: NUMBER OF CASES ELAPSED TIME	139 21.3	773 24.9	299 17.6	356 14.0	509 17.9	1049 18.7	759 11.4	346 16.3	4230 17.9

TABLE 24

DISTRIBUTION OF WEEKEND TRIPS IN THE CHICAGO SURVEY BY TRIP SEGMENT
STRING SHOWING AVERAGE TRIP ELAPSED TIME IN MINUTES PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000- 0829	0830- 1059	1100- 1259	1300- 1759	1800- 2059	2100- 2359	
N: NUMBER OF CASES ELAPSED TIME (MIN)	146 14.0	229 8.3	282 8.9	542 11.1	205 11.6	86 11.8	1490 10.6
NFN: NUMBER OF CASES ELAPSED TIME	25 27.6	24 36.0	34 23.9	61 43.4	32 28.3	19 38.5	195 34.1
NFNFN: NUMBER OF CASES ELAPSED TIME	3 40.3	1 135.0	2 38.6	8 87.0	1 79.7	1 36.9	16 71.6
OTHER: NUMBER OF CASES ELAPSED TIME	0 0	2 3.5	1 143.7	1 1.7	0 0	3 22.0	7 31.2
TOTAL: NUMBER OF CASES ELAPSED TIME	174 16.4	256 11.4	319 11.1	612 15.3	238 14.1	109 17.0	1708 13.9

TABLE 25
AVERAGE ELAPSED TIME IN MINUTES FOR SEGMENTS OF WEEKDAY FREEWAY
TRIPS IN CHICAGO SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT								TOTAL
	0000- 0559	0600- 0859	0900- 1129	1130- 1329	1330- 1629	1630- 1829	1830- 2050	2100- 2359	
NONFREEWAY ¹									
NUMBER OF CASES ELAPSED TIME	74 9.0	562 10.2	132 9.5	103 7.5	182 9.9	440 10.5	159 9.5	93 10.6	1745 9.9
FREEWAY									
NUMBER OF CASES ELAPSED TIME	35 15.3	284 14.0	66 15.5	53 15.0	87 14.1	237 15.1	80 11.4	48 16.1	890 14.4
TOTAL									
NUMBER OF CASES ELAPSED TIME	109 11.0	846 11.5	198 11.5	150 10.0	269 11.3	677 12.1	239 10.1	141 12.5	2635 11.4

¹ EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH N-TRIP SEGMENT SEQUENCE)

TABLE 26
AVERAGE ELAPSED TIME IN MINUTES FOR SEGMENTS OF
WEEKEND FREEWAY TRIPS IN CHICAGO SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT						TOTAL
	0000- 0829	0830- 1059	1100- 1259	1300- 1759	1800- 2059	2100- 2359	
NONFREEWAY ¹							
NUMBER OF CASES ELAPSED TIME	59 6.9	47 10.2	82 8.1	155 11.4	73 9.0	39 8.9	455 9.5
FREEWAY							
NUMBER OF CASES ELAPSED TIME	32 12.6	26 15.9	40 11.4	81 23.2	34 12.8	23 17.3	236 16.9
TOTAL							
NUMBER OF CASES ELAPSED TIME	91 8.9	73 12.2	122 9.2	236 15.4	107 10.2	62 12.0	691 12.0

¹ EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

TABLE 27

DISTRIBUTION OF WEEKDAY TRIPS IN CHICAGO SURVEY BY TRIP
SEGMENT STRING SHOWING AVERAGE NUMBER OF TRIP STOPS WITH ENGINE ON PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000- 0559	0600- 0859	0900- 1129	1130- 1329	1330- 1629	1630- 1829	1830- 2059	2100- 2350	
N: NUMBER OF CASES NUMBER OF STOPS (ENGINE ON)	107 6.0	504 8.1	232 5.5	306 4.6	429 6.3	826 6.3	682 4.1	297 4.5	3383 5.7
NFN: NUMBER OF CASES NUMBER OF STOPS	31 8.5	254 10.7	63 8.8	45 9.3	74 9.8	207 11.4	73 7.9	48 8.7	795 10.1
NFNFN: NUMBER OF CASES NUMBER OF STOPS	1 21.0	14 15.4	3 13.7	4 10.5	6 14.5	9 24.9	2 15.5	1 26.0	40 17.2
OTHER: NUMBER OF CASES NUMBER OF STOPS	0 0	1 6.0	1 8.0	1 13.0	0 0	7 6.9	2 1.0	0 0	12 6.4
TOTAL: NUMBER OF CASES NUMBER OF STOPS	139 6.7	773 9.1	294 6.3	356 5.3	509 6.9	1049 7.5	759 4.5	346 5.1	4230 6.7

TABLE 28

DISTRIBUTION OF WEEKEND TRIPS IN CHICAGO SURVEY BY TRIP
SEGMENT STRING SHOWING AVERAGE NUMBER OF TRIP STOPS WITH ENGINE ON PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000- 0829	0830- 1059	1100- 1259	1300- 1759	1800- 2059	2100- 2359	
N: NUMBER OF CASES NUMBER OF STOPS (ENGINE ON)	146 5.2	229 3.8	282 3.9	542 4.4	205 4.6	86 4.5	1490 4.3
NFN: NUMBER OF CASES NUMBER OF STOPS	25 5.5	24 8.5	34 5.4	61 0.3	32 7.8	19 7.3	195 7.6
NFNFN: NUMBER OF CASES NUMBER OF STOPS	3 7.0	1 8.0	2 9.0	8 15.0	1 24.0	1 10.0	16 12.4
OTHER: NUMBER OF CASES NUMBER OF STOPS	0 0	2 3.5	1 9.0	1 0.0	0 0	3 4.0	7 4.0
TOTAL: NUMBER OF CASES NUMBER OF STOPS	1174 5.3	256 4.3	319 4.1	612 5.0	238 5.1	109 5.0	1708 4.8

TABLE 29
AVERAGE NUMBER OF ENGINE-ON STOPS FOR SEGMENTS OF WEEKDAY
FREEWAY TRIPS IN CHICAGO SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT								TOTAL
	0000- 0559	0600- 0859	0900- 1129	1130- 1329	1330- 1629	1630- 1829	1830- 2059	2100- 2359	
NONFREEWAY ¹									
NUMBER OF CASES	74	562	132	103	182	440	159	93	1745
NUMBER OF STOPS	3.9	4.7	4.0	3.4	4.5	5.0	3.9	4.0	4.5
FREEWAY									
NUMBER OF CASES	35	284	66	53	87	237	80	48	890
NUMBER OF STOPS	1.1	1.2	0.8	1.8	0.8	1.7	1.7	0.3	1.3
TOTAL									
NUMBER OF CASES	109	846	193	156	269	677	239	141	2635
NUMBER OF STOPS	3.0	3.5	2.9	2.9	3.3	3.8	3.2	2.7	3.4

¹ EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

TABLE 30
AVERAGE NUMBER OF ENGINE-ON STOPS FOR SEGMENTS OF WEEKEND
FREEWAY TRIPS IN CHICAGO SURVEY BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT						TOTAL
	0000- 0829	0830- 1059	1100- 1259	1300- 1759	1800- 2059	2100- 2359	
NONFREEWAY ¹							
NUMBER OF CASES	59	47	82	155	73	39	455
NUMBER OF STOPS	2.5	3.6	2.6	4.0	3.7	3.1	3.4
FREEWAY							
NUMBER OF CASES	32	26	40	81	34	23	236
NUMBER OF STOPS	0.5	1.5	0.3	1.0	0.8	1.2	0.9
TOTAL							
NUMBER OF CASES	91	73	122	236	107	62	691
NUMBER OF STOPS	1.8	2.9	1.8	3.0	2.8	2.4	2.5

¹ EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

Tables 31 and 32 show mean measured idling time for weekday and weekend trips while Tables 33 and 34 show similar data for segments of freeway trips.

Most trips in the Chicago survey showed zero measured idling time. Over 90% of all trips had less than a minute (92.5% for weekdays and 94.1% for weekends). Nevertheless, there were cases of idling periods of considerable length, no doubt largely due to warm-up periods at the beginning of trips due to the cold weather. Almost 2% of the weekday trips and 1% of the weekend trips showed idle time in excess of 10 minutes! As a result, the mean idling period for weekday trips turned out to be 0.6 minute and for weekend trips 0.5 minute.

Elapsed Time Between Trips

Figures 22 and 23 show the distribution of elapsed time between trips for weekday and weekend. The time scale on each figure is broken in several places: at one hour, to enable a more precise breakdown of shorter inter-trip times; and at daily intervals from two to six days to enable the agglomeration of larger intertrip times. Tables 35 and 36 show the breakdown of elapsed time from last trip by time slot and purpose of trip for weekday and weekend trips. Since this quantity is not associated with the trip segment structure but is quite clearly associated with trip purpose, we believe this breakdown is more reasonable than that based upon the time slot/trip segment string criterion used previously.

In addition to this quantity, the survey results also contain data on the incidence of engine-off stops of less than five minutes. This quantity does not show up as an elapsed time between trips since if such a stop occurred, the computer program merged the two trips into a single record. The incidence of such stops was very meager. Table 37 shows the results for weekdays and weekend trips.

November 26, 1969

-64-

TM-(L)-4119/003/00

TABLE 31

DISTRIBUTION OF WEEKDAY TRIPS IN CHICAGO SURVEY BY TRIP SEGMENT
 STRING SHOWING AVERAGE MEASURED IDLING TIME IN MINUTES PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000- 0559	0600- 0859	0900- 1129	1130- 1329	1330- 1629	1630- 1829	1830- 2059	2100- 2359	
N: NUMBER OF CASES AVERAGE IDLING TIME	107 1.5	504 0.8	232 0.9	306 0.9	429 0.5	826 0.4	682 0.3	297 0.5	3383 0.6
NFN: NUMBER OF CASES AVERAGE IDLING TIME	31 1.0	254 0.6	63 2.1	45 0.0	74 0.7	207 0.5	73 0.9	48 0.5	795 0.7
NFNFN: NUMBER OF CASES AVERAGE IDLING TIME	1 5.0	14 0.2	3 9.6	4 0.0	6 0.0	0 0.6	2 0.0	1 0.0	40 1.1
OTHER: NUMBER OF CASES AVERAGE IDLING TIME	0 0	1 0.0	1 0.0	1 0.0	0 0	7 0.0	2 0.0	0 0.0	12 0.0
TOTAL: NUMBER OF CASES AVERAGE IDLING TIME	139 1.4	773 0.7	299 1.2	356 0.8	509 0.5	1049 0.4	759 0.4	346 0.5	4230 0.6

TABLE 32

DISTRIBUTION OF WEEKEND TRIPS IN CHICAGO SURVEY BY TRIP SEGMENT
 STRING SHOWING AVERAGE MEASURED IDLING TIME IN MINUTES PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000- 0829	0830- 1059	1100- 1259	1300- 1759	1800- 2059	2100- 2359	
N: NUMBER OF CASES AVERAGE IDLING TIME	146 0.6	229 0.5	282 0.2	542 0.7	205 0.3	86 0.5	1490 0.5
NFN: NUMBER OF CASES AVERAGE IDLING TIME	25 0.1	24 2.6	34 0.2	61 0.5	32 1.0	19 0.7	195 0.6
NFNFN: NUMBER OF CASES AVERAGE IDLING TIME	3 0.0	1 0.0	2 0.0	8 0.0	1 0.0	1 0.0	16 0.0
OTHER: NUMBER OF CASES AVERAGE IDLING TIME	0 0	2 0.0	1 0.0	1 0.0	0 0.0	3 0.0	7 0.0
TOTAL: NUMBER OF CASES AVERAGE IDLING TIME	174 0.5	256 0.7	319 0.2	612 0.7	238 0.4	109 0.5	1708 0.5

TABLE 33
AVERAGE MEASURED IDLING TIME IN MINUTES FOR SEGMENTS
OF WEEKDAY FREEWAY TRIPS IN CHICAGO BY TIME SLOT AND ROUTE TYPE

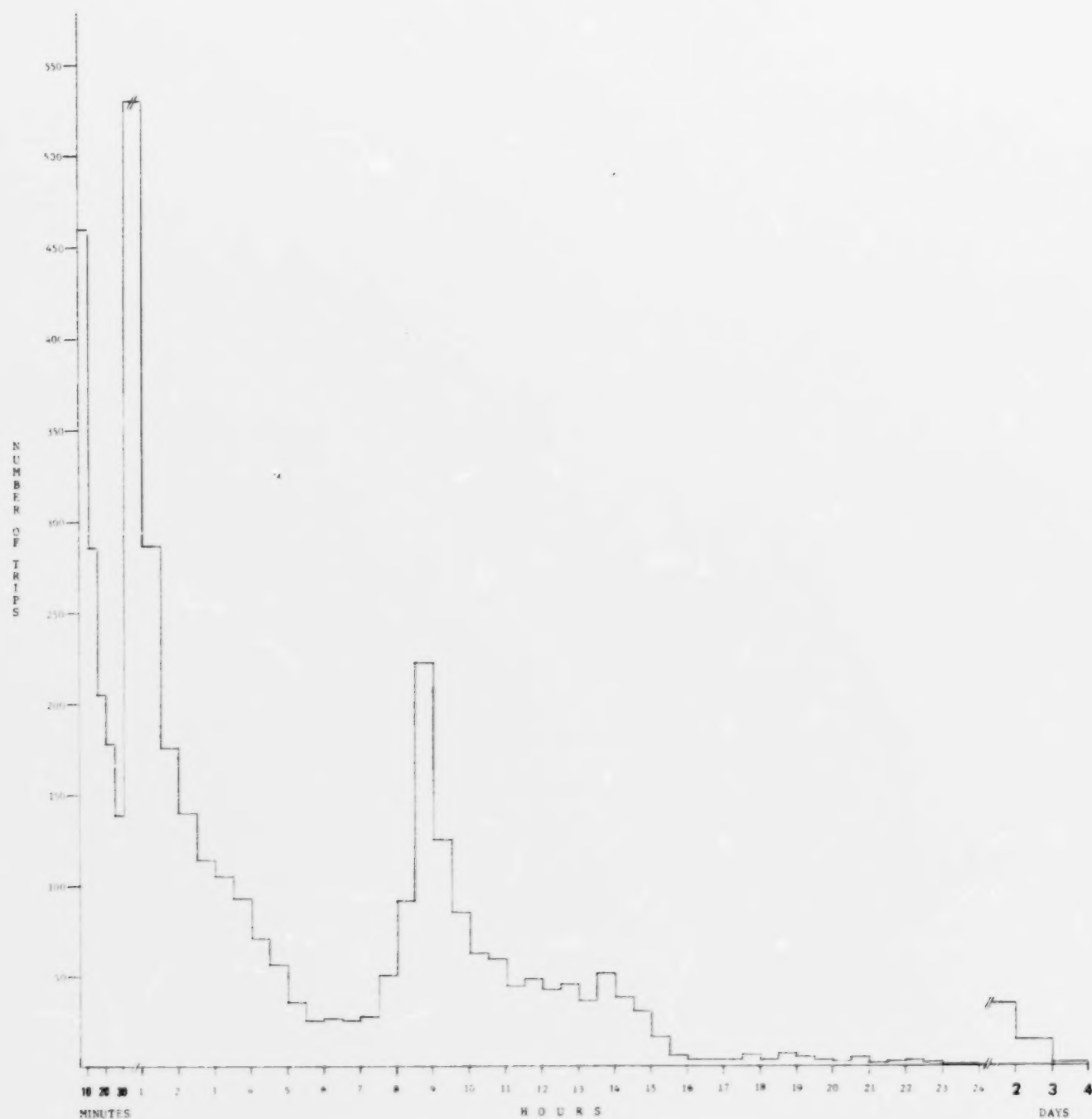
ROUTE TYPE	TIME SLOT								TOTAL
	0000- 0559	0600- 0859	0900- 1129	1130- 1329	1330- 1629	1630- 1829	1830- 2059	2100- 2359	
NONFREEWAY ¹									
NUMBER OF CASES	74	562	132	103	182	440	159	93	1745
AVG IDLING TIME	0.3	0.3	1.0	0.0	0.3	0.2	0.4	0.3	0.3
FREEWAY									
NUMBER OF CASES	35	284	66	53	87	237	80	48	890
AVG IDLING TIME	0.1	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL									
NUMBER OF CASES	109	846	198	156	269	677	239	141	2635
AVG IDLING TIME	0.2	0.2	0.8	0.0	0.2	0.1	0.3	0.2	0.2

¹ EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

TABLE 34
AVERAGE MEASURED IDLING TIME IN MINUTES FOR SEGMENTS
OF WEEKEND FREEWAY TRIPS IN CHICAGO BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT						TOTAL
	0000- 0829	0830- 1059	1100- 1259	1300- 1759	1800- 2059	2100- 2359	
NONFREEWAY ¹ NUMBER OF CASES AVG IDLING TIME	59 0.0	47 0.8	82 0.6	155 0.1	73 0.3	39 0.1	455 0.3
FREEWAY NUMBER OF CASES AVG IDLING TIME	32 0.0	26 0.0	40 0.0	81 0.0	34 0.3	23 0.3	236 0.1
TOTAL NUMBER OF CASES AVG IDLING TIME	91 0.0	73 0.5	122 0.4	236 0.1	107 0.3	62 0.2	691 0.2

¹ EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS
(I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)



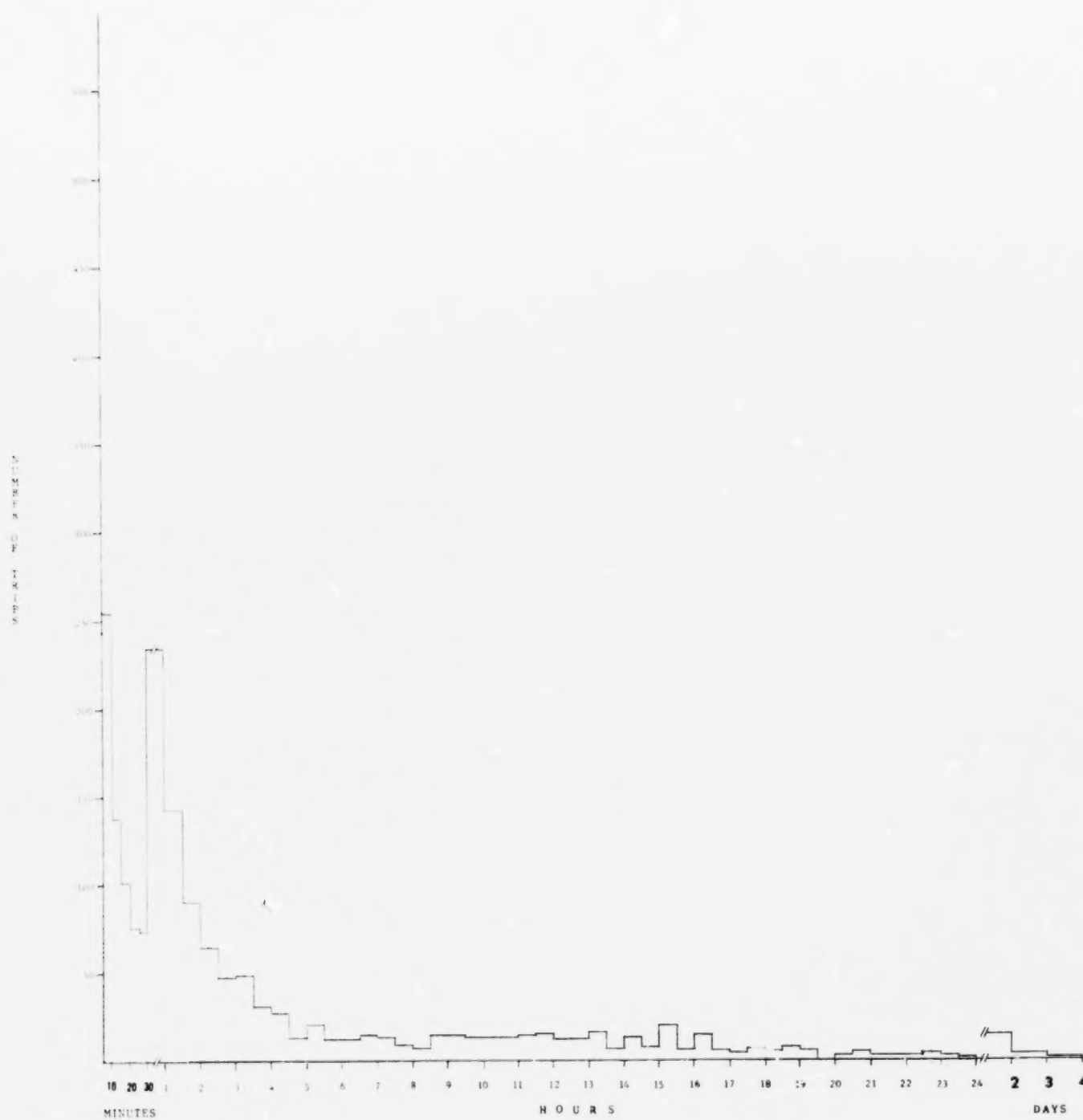


FIGURE 23
DISTRIBUTION OF ELAPSED TIME BETWEEN TRIPS, WEEKEND

November 26, 1969

-69-

TM-(L)-4119/003/00

TABLE 35

AVERAGE ELAPSED TIME SINCE LAST TRIP FOR WEEKDAY
TRIPS IN CHICAGO SURVEY BY TIME SLOT AND PURPOSE

PURPOSE OF TRIP	TIME SLOT								TOTAL
	0000- 0559	0600- 0859	0900- 1129	1130- 1329	1330- 1629	1630- 1829	1830- 2059	2100- 2359	
GO HOME	20 2:09	41 3:04	47 1:16	34 2:06	178 3:25	513 4:58	301 1:36	234 2:24	1368 3:17
GO TO WORK	59 7:38	563 10:56	41 5:08	79 3:01	51 5:09	51 5:29	12 2:34	7 7:17	863 8:54
BUSINESS	37 5:48	86 5:09	136 3:03	134 2:19	133 2:22	73 3:33	60 1:31	23 2:58	682 3:06
SHOPPING	16 3:39	66 5:59	53 4:41	88 2:28	110 4:28	287 3:20	239 1:32	31 1:51	890 3:08
CHURCH, SCHOOL, ETC.	1 0:58	8 5:38	7 10:45	2 2:33	6 3:29	20 2:17	15 3:17	1 4:13	60 4:33
RECREATION	6 2:18	9 8:01	15 3:21	19 2:21	31 2:27	105 2:55	132 1:38	50 1:57	367 2:23
TOTAL	139 5:37	773 9:24	299 3:32	356 2:29	509 3:29	1049 4:11	759 1:38	346 2:26	4230 4:10

TABLE 36

AVERAGE ELAPSED TIME SINCE LAST TRIP FOR WEEKEND
TRIPS IN CHICAGO SURVEY BY TIME SLOT AND PURPOSE

PURPOSE OF TRIP	TIME SLOT						TOTAL
	0000- 0829	0830- 1059	1100- 1259	1300- 1759	1800- 2059	2100- 2359	
GO HOME	46 2:36	67 1:32	109 1:57	203 1:38	98 2:12	68 2:15	591 1:70
GO TO WORK	27 7:44	13 12:37	12 5:17	7 5:11	3 12:11	3 6:22	65 7:92
BUSINESS	19 4:39	17 5:09	17 3:21	34 2:19	6 1:11	3 8:59	96 3:45
SHOPPING	41 7:07	108 6:49	122 4:30	206 3:36	60 2:19	11 2:41	548 4:37
CHURCH, SCHOOL, ETC.	16 8:08	21 13:34	10 5:05	9 0:45	4 2:17	1 1:21	61 7:77
RECREATION	25 4:31	30 8:16	49 4:28	15 3:33	67 1:41	23 1:51	347 3:46
TOTAL	174 5:29	256 6:10	319 3:36	612 2:61	238 2:04	109 2:30	1708 3:45

TABLE 37

NUMBER OF CASES OF ENGINE-OFF STOPS
FOR WEEKDAY AND WEEKEND TRIPS IN CHICAGO SURVEY

NUMBER OF STOPS	NUMBER OF TRIPS	
	WEEKDAY	WEEKEND
0	4005 (95%)	1588 (93%)
1	201 (4%)	113 (7%)
2	24 (1%)	7 (-)

Parking

The results obtained on parking habits during the survey indicate a high likelihood that most residents in the Cincinnati area leave their cars outdoors both at night and between trips. The percentage of indoor parkers is, however, higher than in previously studied cities. Table 38 shows the results for weekdays and weekends. Survey participants were told that only closed garages constituted indoor parking.

TABLE 38

INDOOR AND OUTDOOR PARKING OVERNIGHT AND BETWEEN TRIPS FOR WEEKDAYS AND WEEKEND DAYS IN CHICAGO SURVEY

	INDOOR	OUTDOOR
WEEKDAYS:		
BETWEEN TRIPS	366 (8.6%)	3864 (91.4%)
OVERNIGHT	276 (32.3%)	579 (67.7%)
WEEKEND DAYS:		
BETWEEN TRIPS	109 (6.4%)	1599 (93.6%)
OVERNIGHT	73 (21.3%)	269 (78.7%)

Overnight Fuel Tank Readings

Table 39 shows the percentage of fuel tank readings at the empty, one-quarter, one-half, three-quarter, and full levels for weekdays and weekend days. Survey participants were asked to note the reading at the start of the day's travel.

TABLE 39

OVERNIGHT FUEL TANK READINGS FOR WEEKDAYS AND WEEKEND DAYS IN
CHICAGO SURVEY (EXPRESSED AS A PERCENTAGE OF CAR-DAYS FOR THE TWO CATEGORIES)

READING	PERCENTAGE OF CAR-DAYS	
	WEEKDAY	WEEKEND
EMPTY	3.1%	4.2%
1/4	23.0%	19.3%
1/2	27.9%	23.1%
3/4	22.5%	27.3%
FULL	23.5%	26.1%

Use of Freeways Versus Surface Streets

Approximately 80% of all weekday trips and 87% of all weekend trips in the Chicago survey were made entirely on surface streets. The previous tables showing the breakdown of trip descriptor variables by trip segment string indicate that the freeway trip is both longer and carried out at a greater average speed than the nonfreeway trip.

As in the previous three studies, Figures 24 through 31 were prepared to assist in determining whether the driver tends to use a freeway because of the greater distance he must cover or because of the speed advantage he may obtain. The figures show the distribution of trip distance for nonfreeway and freeway trips by three-mile increments within each of the eight weekday time slots. While all of the charts are not entirely similar, they continue in general to show the trend established in Los Angeles, Houston, and Cincinnati. Basically all, with the major exception of time slot one (Figure 24), show an exponentially-shaped frequency function for the combination of all trips, nonfreeway and freeway. The frequency distribution function for freeways tends, however, to be bell-shaped, indicating that the freeway driver tends to select his route because of the distance he must travel.

During the Chicago survey, 20,000 miles out of the total 40,000 miles driven by survey participants (49%) were on trips that involved freeway segments and 11,000 of these were actual freeway miles. The 49% represents a decrease from the Los Angeles and Houston values of 68% and 56% respectively, but is above the Cincinnati value of 42%.

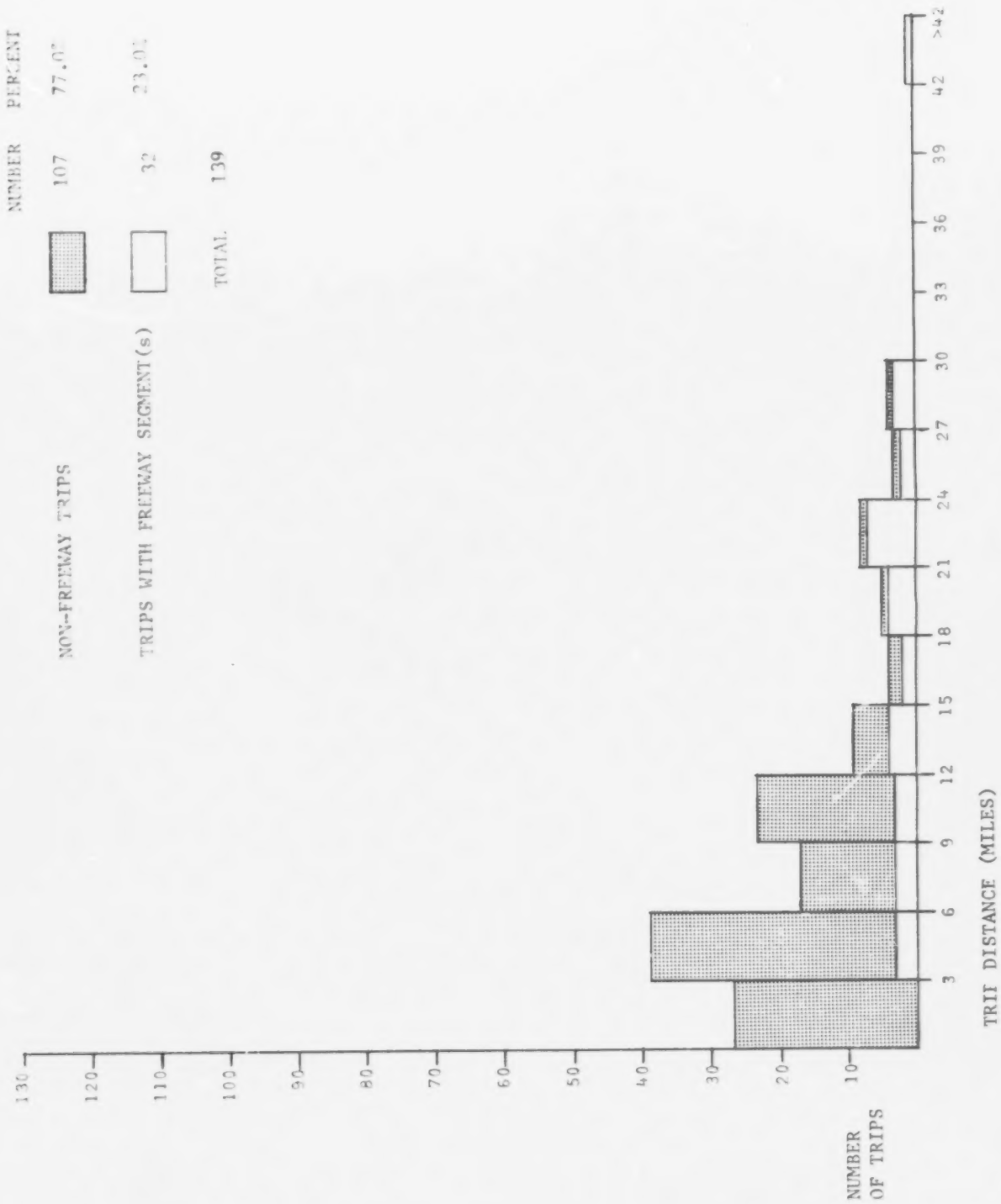


FIGURE 24
DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT ONE (0000 - 0559)
SHOWING DIVISION BETWEEN FREEMAY AND NON-FREEMAY TRIPS

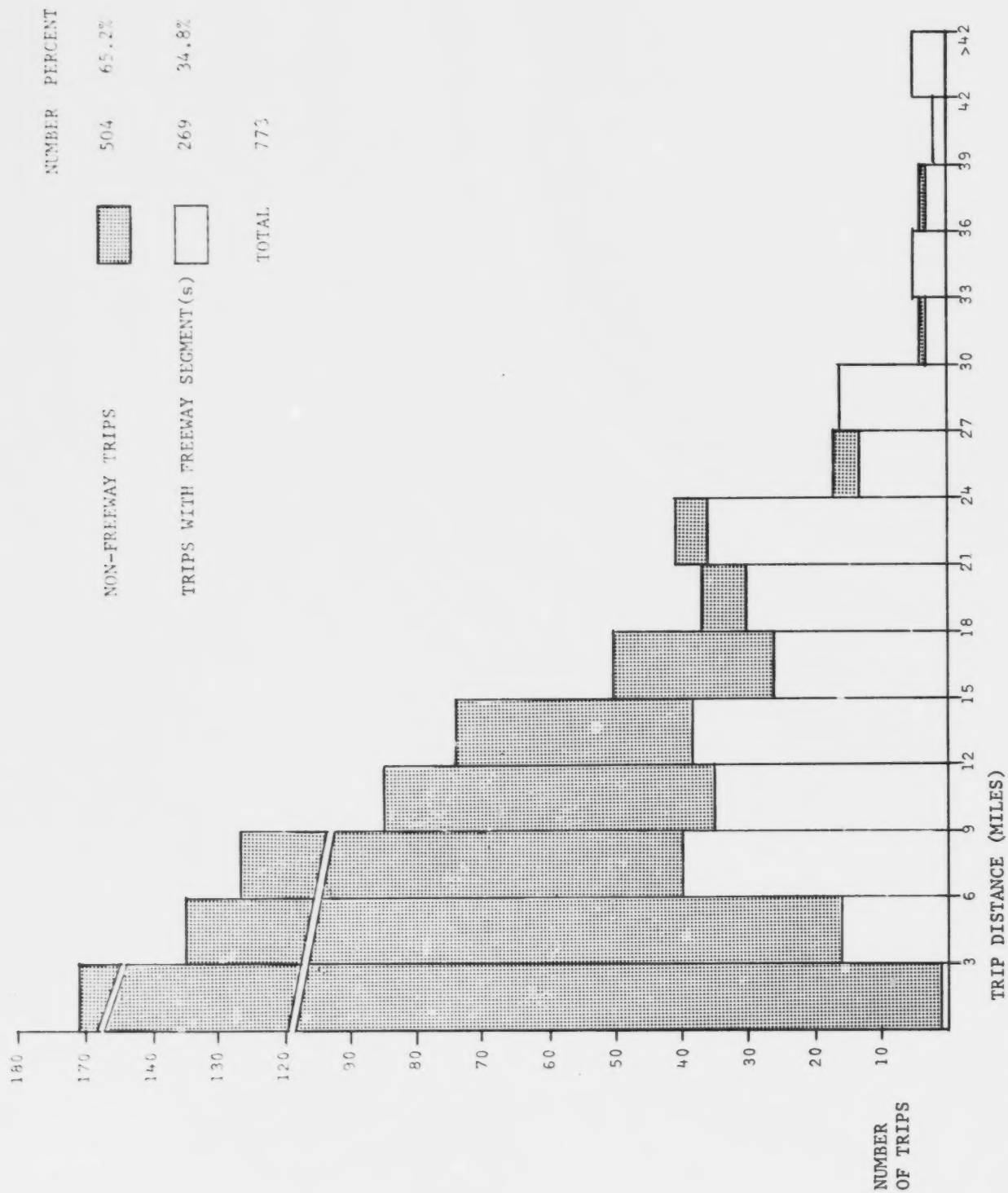


FIGURE 25

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT TWO (0600 - 0859)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

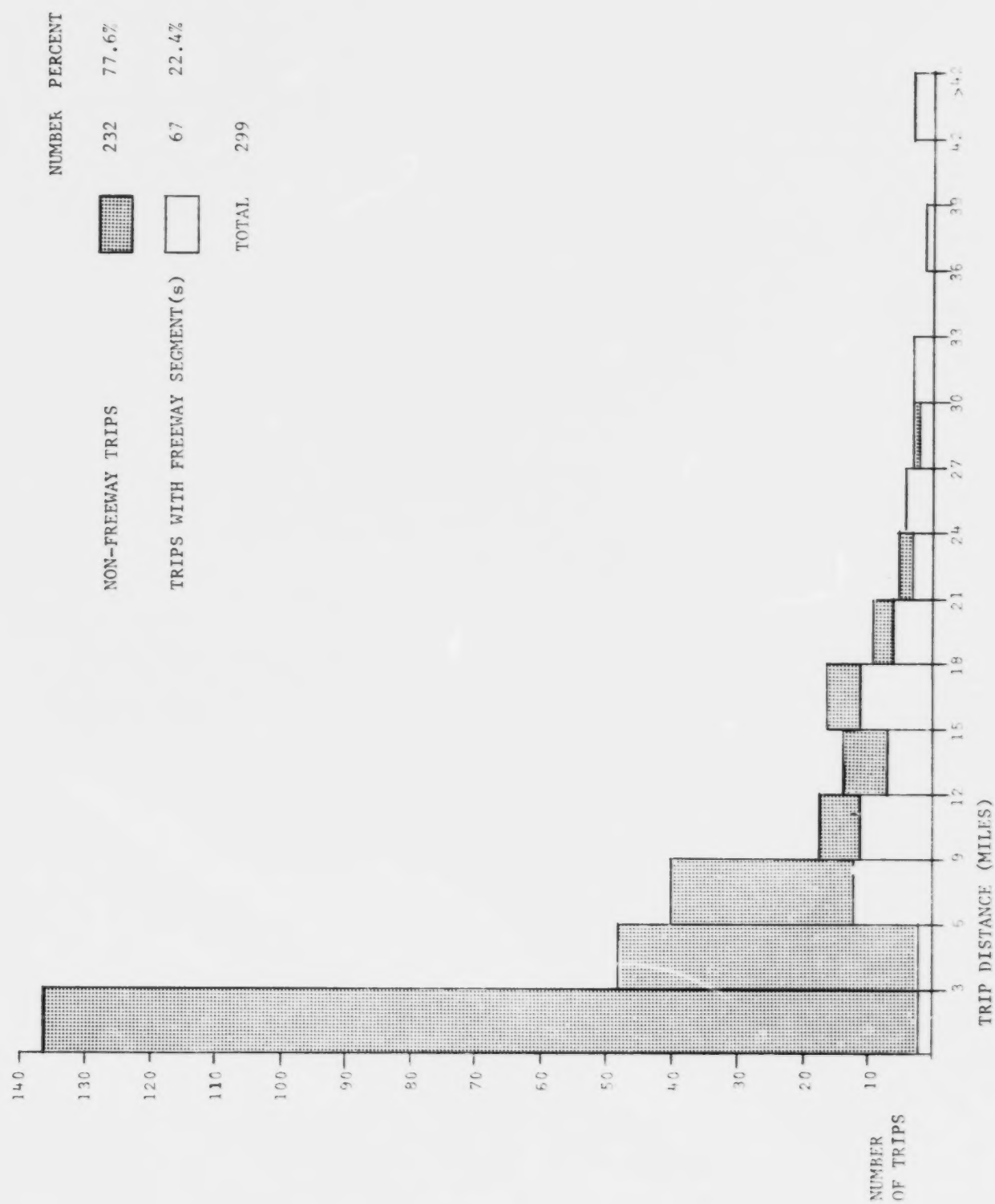


FIGURE 26
DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT THREE (0900 - 1129)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

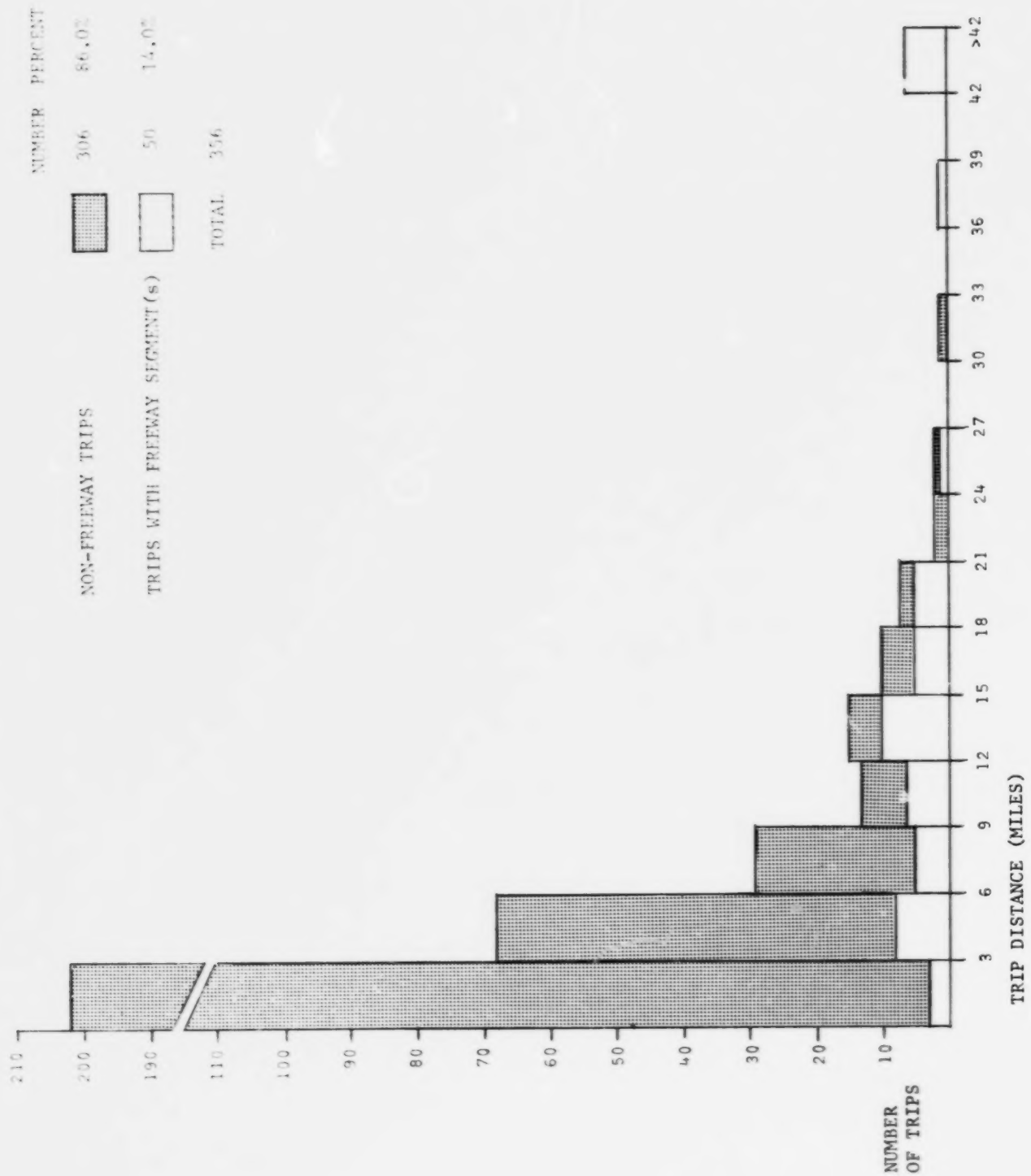


FIGURE 27
DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT FOUR (1130 - 1329)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

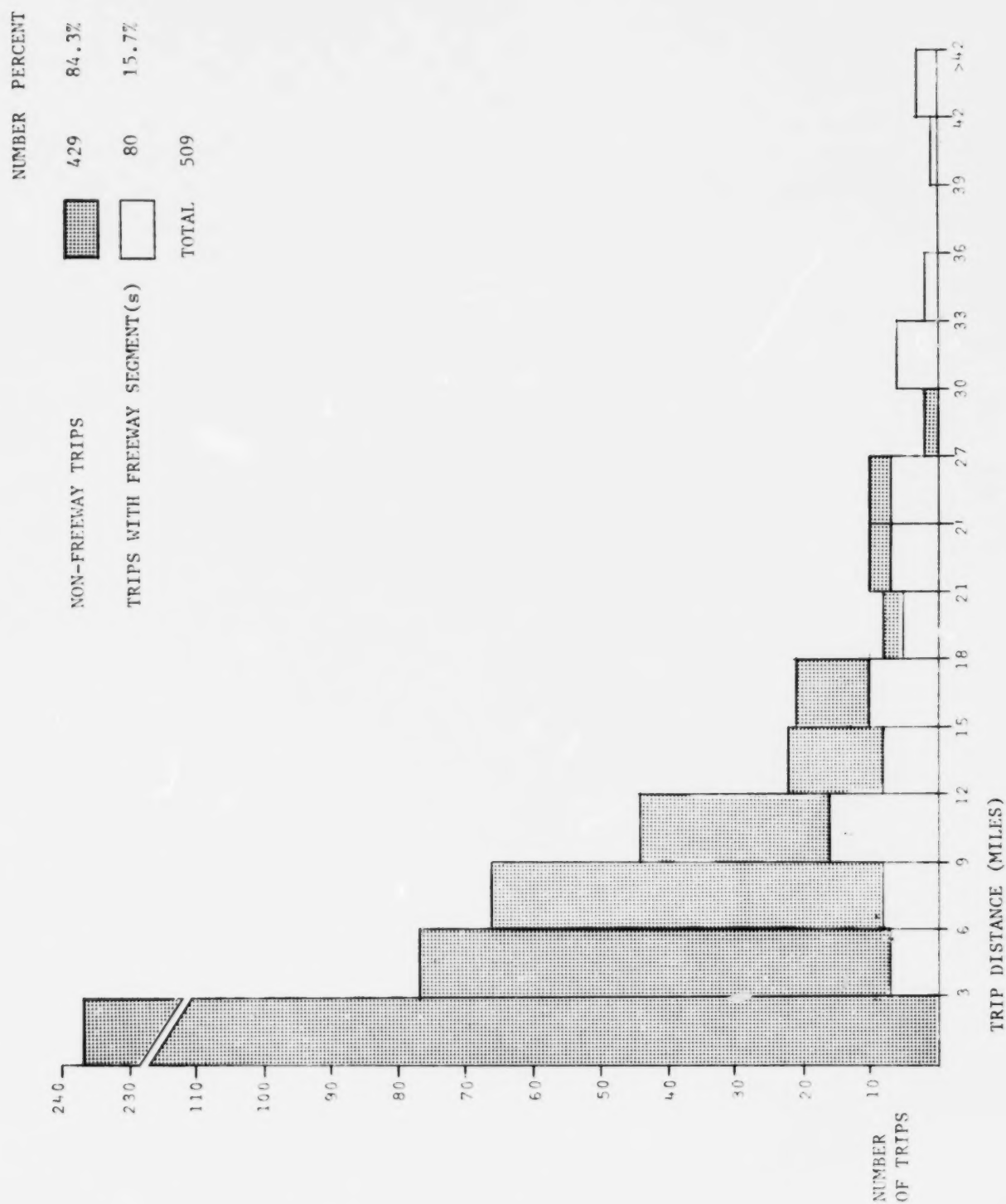
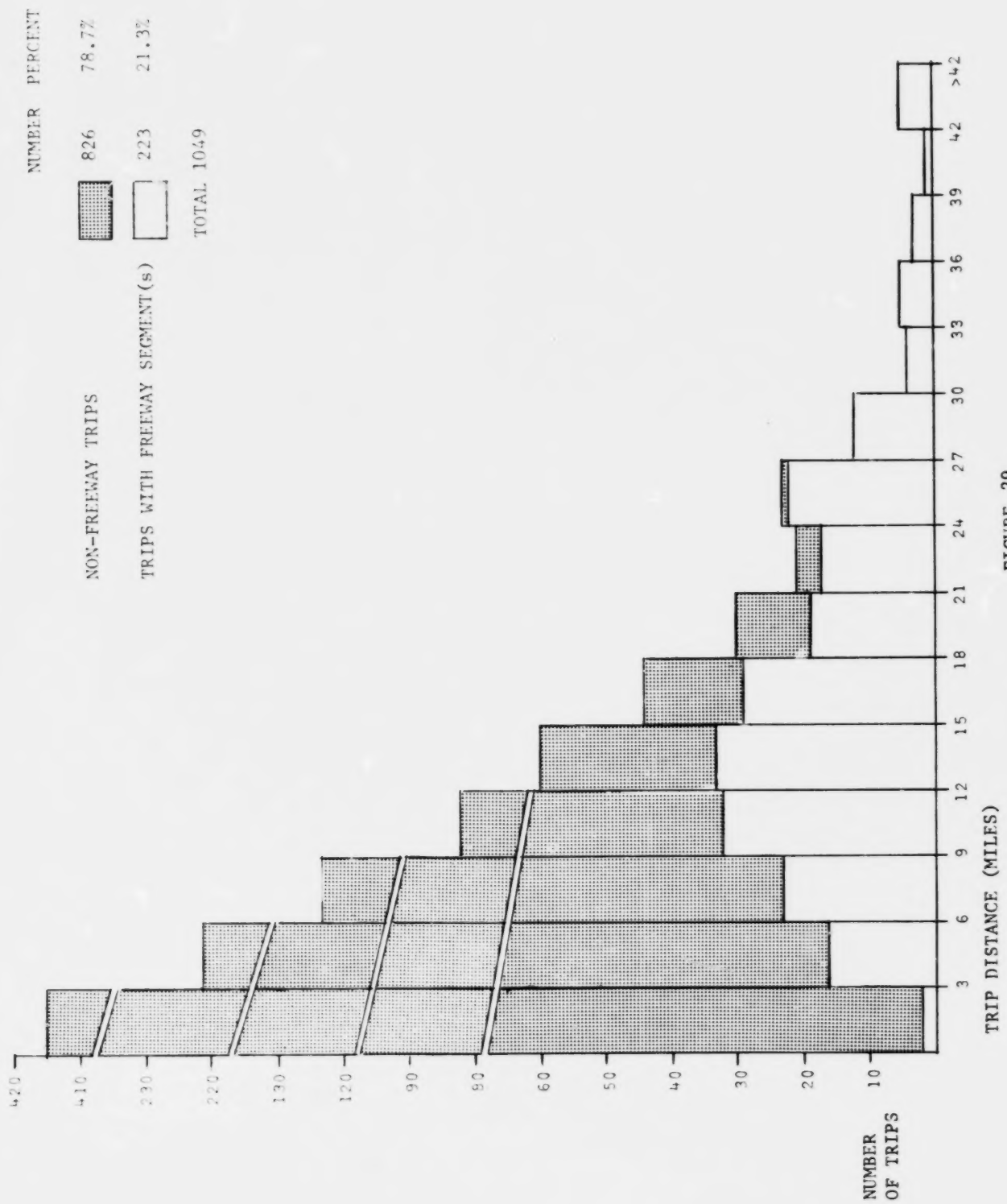


FIGURE 28

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT FIVE (1330 - 1629)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS



DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT SIX (1630 - 1829)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

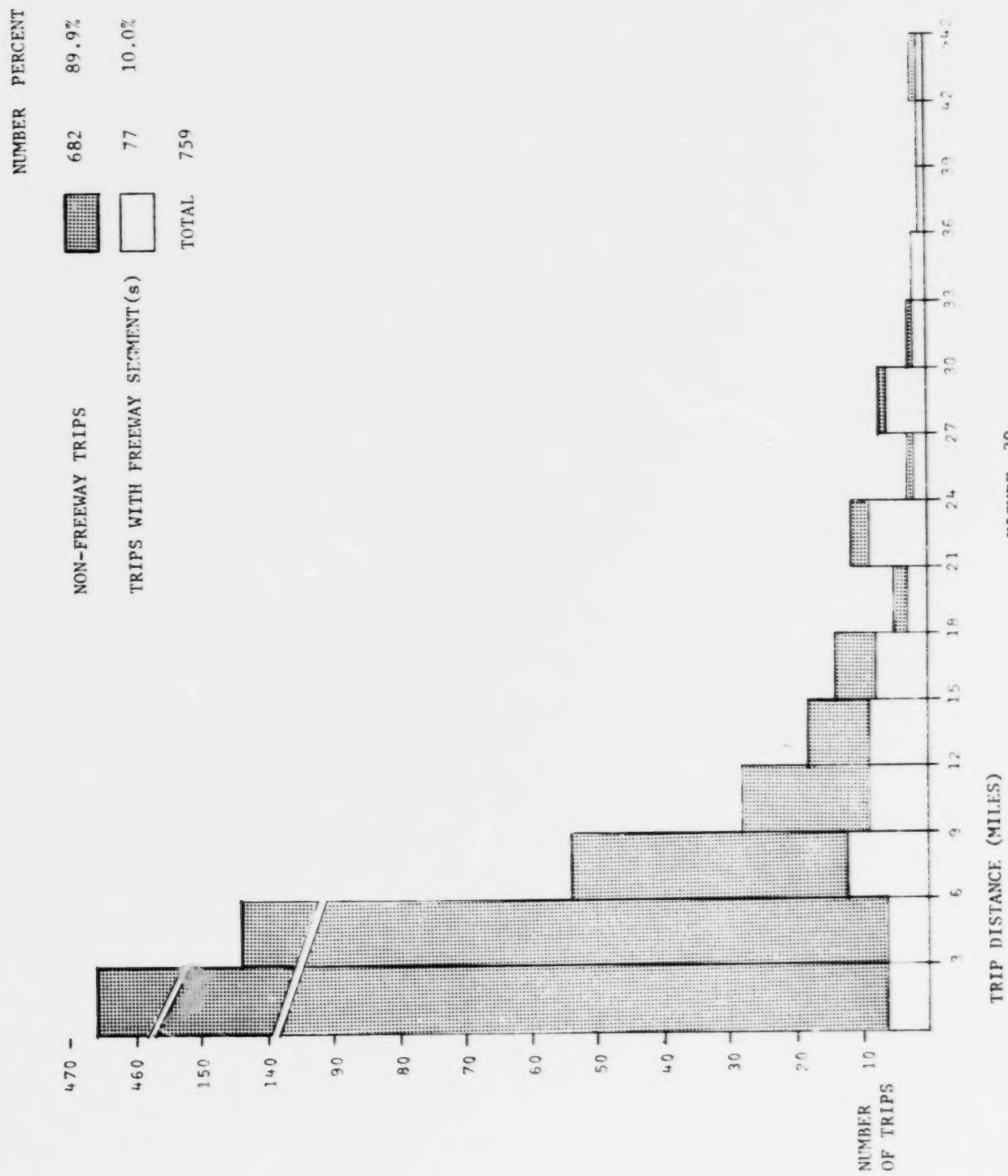


FIGURE 30
DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT SEVEN (1830 - 2059)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

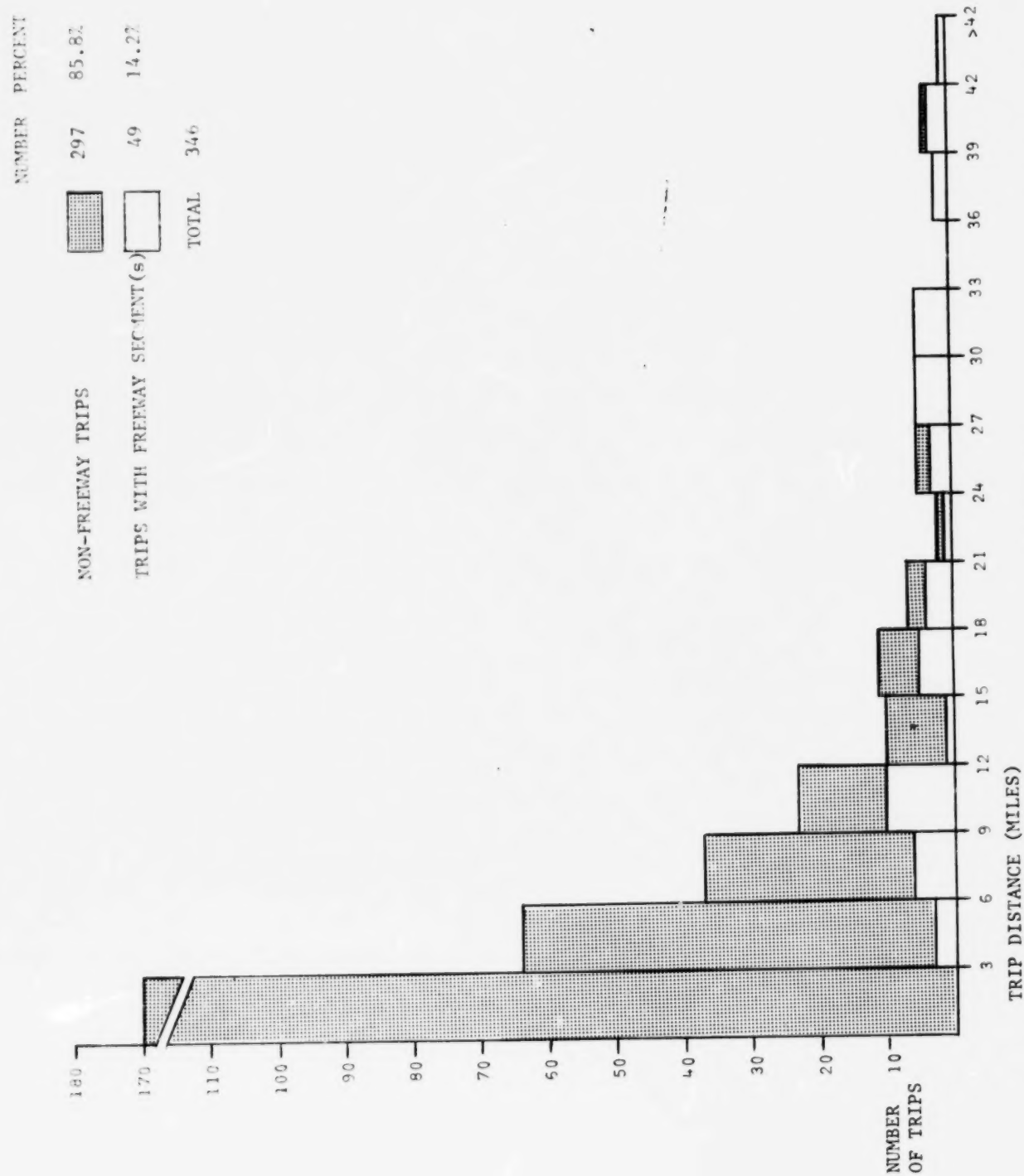


FIGURE 31
DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT EIGHT (2100 - 2359)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

COMPARISON OF CHICAGO, CINCINNATI, HOUSTON AND LOS ANGELES RESULTS

This section of the report compares the results obtained in the Chicago survey with those obtained in the Los Angeles, Houston and Cincinnati surveys. It is divided into three discussion areas: n-trip day patterns, automobile utilization, and trip descriptors. The principal approach compares the frequency distributions of specific variables obtained in the samples of four cities. Formally stated, the basic hypothesis being tested in each case is whether the four samples are drawn from populations that are homogeneous with respect to the variable being considered. Since the Driving Patterns Survey is concerned with the overall spectrum of driving characteristics rather than with the statistical averages that theoretically represent those statistics in some mathematical sense, we believe that the comparison of distributions provides a more valid basis for statistical inference than the comparison of sample means and standard deviations. Therefore, if statistical tests applied to four samples do not reject the hypothesis of homogeneity, no further testing is carried out. If the hypothesis is rejected, then three-way combinations of Chicago and two of the remaining cities are tested to see if they represent homogeneous populations. If the hypothesis is rejected in these tests, pairwise combinations of Chicago with each city are tested to see which one most closely resembles Chicago in the distributions of the particular variable being tested. If, finally, these hypotheses are rejected, the data are examined to determine the reason for rejection and weaker (perhaps less relevant) hypotheses about the equality of sample means are made and tested. In all the statistical tests described, we used an α of 0.05. Thus, if a test indicates that a hypothesis should be rejected, the probability is only 0.05 that the test has rejected a valid hypothesis.

The comparisons of distributions for homogeneity employ the Kolmogorov-Smirnov statistic for variables with underlying distributions that are continuous and the Chi-Square Test of Homogeneity for Variables with discrete distributions. Other tests used for comparisons are described as they are used.

N-Trip Day Patterns

Table 40 shows the percentage of total n-trip days and total car-weekdays represented by those cars that drove the typical n-trip patterns. (In Volume 0, results for Los Angeles indicated n-trip pattern days as a percentage of total car-days. The values in Table 40 have been normalized to total car-weekdays to make them comparable to the Chicago, Cincinnati, and Houston results.)

The results in Table 40 show that the percentages of typical n-trip pattern days in Chicago vary considerably from those in the three previously studied cities. In Chicago, n-trip pattern days account for 24% of the total car-weekdays. This value corresponds to values of 26% for Cincinnati, 30% for Houston and 18% for Los Angeles. Chi-square tests of the homogeneity of the four cities with respect to the distribution of n-trip pattern days as a percentage of total n-trip days as well as total car-weekdays reject the hypothesis for all city combinations except the Chicago-Cincinnati pairwise combination.

Automobile Utilization

Automobile utilization is characterized by the number of trips driven per day, the times at which they are driven, their purpose, and the types of routes taken. The results of the survey in Chicago show that in most respects automobile utilization is significantly different, in the statistical sense, than in the previously surveyed cities. By this, we mean that the populations of the four cities cannot be considered to be drawn from a homogeneous population.

The numbers of n-trip days (both weekdays and weekend days) in the four cities were compared using a chi-square test. The hypothesis of homogeneity was rejected at the $\alpha = 0.05$ level as well as the $\alpha = 0.01$ level. Similar

TABLE 40
 N-TRIP PATTERN CAR DAYS AS A PERCENTAGE OF ALL N TRIP DAYS AND
 ALL CAR-WEEKDAYS IN THE LOS ANGELES, HOUSTON, CINCINNATI AND CHICAGO SURVEYS

N-TRIP PATTERN	PERCENT OF N-TRIP DAYS				PERCENT OF CAR-WEEKDAYS			
	LOS ANGELES	HOUSTON	CINCINNATI	CHICAGO	LOS ANGELES	HOUSTON	CINCINNATI	CHICAGO
2	44-54%	64-86%	44-57%	62-74%	8.8-11.0%	13.5-18.1%	10.0-12.9%	9.2-11.1%
3	18%	45%	28%	29%	2.3%	5.0%	4.0%	3.5%
4 (Evening)	12%	29%	30%	32%	2.2%	5.3%	5.4%	6.7%
4 (Noon)	13%	14%	8%	6%	2.1%	2.7%	1.5%	1.1%
5 (Evening-Shop)	16%	23%	22%	19%	1.9%	3.1%	2.9%	3.0%
5 (Work-Shop)	0%	0%	13%	0%	0.0%	0.0%	1.8%	0.0%

tests on three-way combinations of cities also rejected the hypothesis at the same α levels. In pairwise combination tests, the hypothesis was not rejected for the Chicago-Houston combination although it was for the other two combinations. The principal reason for rejection is that in Chicago the distribution of n-trip days is considerably different than in the other cities. The modal value for n in Chicago is four. It is two in the other cities. The difference between the number of three-trip days and two-trip days in Chicago is much less than in the other cities. Proportionately, there are more five- and six-trip days in Chicago than in the other cities. Finally, the maximum number of trips is 22 in Chicago compared to 17 in the other three cities.

A chi-square test of the division of trips between weekdays and weekend days in the four cities rejected the hypothesis of homogeneity. Three-way tests similarly rejected the hypothesis. Two-way tests failed to reject the hypothesis for the Chicago-Houston combination and for the Chicago-Cincinnati combination if the α level was reduced to 0.01. Chicago and Los Angeles were shown to be nonhomogeneous.

The time distribution of trips was tested first by time slot, then by the distribution of trip start times over 15-minute intervals throughout the day for both weekday and weekend trips. The time slot loadings in the four cities were tested with a chi-square test. For weekday trips, these tests rejected the hypothesis of homogeneity under all possible city combinations. Trips in Chicago were distributed more similarly to those in Cincinnati than to those in any other city. There were, however, sufficiently more early morning and midday trips, proportionately, in Chicago than in Cincinnati that the chi-square test of the two distributions rejected the basic hypothesis.

The time slot loading on weekends showed a somewhat anomalous condition. The four-way test of homogeneity rejected the hypothesis, but all three tests of Chicago paired with two of the remaining cities failed to reject the hypothesis

at the $\alpha = 0.01$ level. Pairwise tests resulted in rejection of the basic hypothesis in the Chicago-Houston combination, failure to reject in the Chicago-Cincinnati combination, and rejection at the $\alpha = 0.05$ level but not at the $\alpha = 0.01$ level for the Chicago-Los Angeles combination.

The test of the four-city combination with respect to the distribution of trip start times over 15-minute intervals resulted in rejection of the hypothesis of homogeneity at the $\alpha = 0.05$ level but failure to reject at the $\alpha = 0.01$ level. This particular test is interesting because pairwise tests between Chicago and each of the remaining cities result in the rejection of the basic hypothesis in all cases. Thus, the distribution of trip start times in Chicago is statistically different from that in each other city but taken together the four cities constitute a homogeneous sample. The interesting result comes about because the cumulative frequency distribution in Chicago lies midway between that of Cincinnati and that of the Houston-Los Angeles combination.

A test of the homogeneity of trip start times on the weekend fails to reject the hypothesis for any combination of cities at the $\alpha = 0.05$ level.

Tests on the distribution of trip purpose show large and significant differences in all cases but one. In the four- and three-city combinations the hypothesis of homogeneity was rejected at both α levels. For pairwise combinations, the hypothesis was rejected significantly in the Chicago-Cincinnati and Chicago-Los Angeles combinations but was only barely rejected at the $\alpha = 0.01$ level in the Chicago-Houston combination. In the case of Chicago and Cincinnati, Chicago drivers made proportionately more business trips and fewer school trips than their Cincinnati counterparts. In the Chicago-Los Angeles comparison, Chicago drivers made significantly fewer work and recreation trips, but significantly more business and school trips than did drivers in Los Angeles.

On weekends, the basic hypothesis was rejected for the four-way combination of cities and for two of the three-way combinations. However, for the Chicago-Cincinnati-Houston combination, the test failed to reject the hypothesis at either α level. In pairwise tests, only the Chicago-Los Angeles combination (where Chicago drivers made more work, business and

school trips; fewer recreation trips) was there a significant rejection of the hypothesis.

Tests on the distribution of freeway versus nonfreeway trips in the four cities showed that there are significant differences between them. For all combinations except the Chicago-Cincinnati pair the hypothesis of homogeneity was rejected by a considerable margin. The basic ratio between nonfreeway and freeway trips in Chicago is 80%/20%, the same as in Cincinnati. This contrasts with the 68%/32% division in Los Angeles and the 70%/30% division in Houston.

On weekends, the ratio of nonfreeway to freeway trips increases to 87%/13% compared to 86%/14% in Cincinnati, 78%/22% in Houston and 81%/19% in Los Angeles. Again, the tests of homogeneity reject the hypothesis for all combinations except the Chicago-Cincinnati pair.

Trip Descriptors

The pattern of statistically significant differences that show up in the previously described tests continues in tests of homogeneity with respect to trip descriptor variables in Chicago, Cincinnati, Houston and Los Angeles. The trip descriptors we will discuss are elapsed time between trips (soak times), trip distance, trip elapsed time, trip stops with engine running, and trip average speed. In addition, tests are made on the results of indoor-outdoor parking and overnight fuel tank readings.

The test for homogeneity of elapsed time between trips rejected the hypothesis for all city combinations for weekday trips. The cause here is related to the greater trip generation rate in Chicago. Since the average driver made more trips per day, the average elapsed time between trips was shorter (4.3 hours versus 4.9 hours in Cincinnati, 5.0 hours in Houston and 5.2 hours in Los Angeles). The distribution of these times shows a greater number of small values in Chicago than in the other cities. Consequently, the test of homogeneity fails in all cases.

On weekends the story is different. The test on the four-city combination fails to reject the hypothesis at $\alpha = 0.01$ although rejection does occur at $\alpha = 0.05$. Only in the Chicago-Los Angeles pairwise combination is the hypothesis rejected at both α levels.

With respect to trip distance, the margin by which the four-way test rejects the hypothesis of homogeneity at the $\alpha = 0.01$ level is very slight, amounting to a difference of only 14 cars. Therefore, one can almost say that the four cities are homogeneous here. Tests on three-way city combinations reject the hypothesis more strongly except in the Chicago-Cincinnati-Los Angeles combination where the hypothesis is not rejected at either the $\alpha = 0.05$ or the $\alpha = 0.01$ levels. In pairwise combinations, Chicago and Los Angeles can be considered as a homogeneous sample, but not the other two pairs. Calculation of the 95% confidence bands for weekday trip distances in the four cities show that only Chicago and Los Angeles overlap. Cincinnati lies below these two bands and Houston lies above them.

Tests on weekend trip distance shows that all cities may be considered as homogeneous in all possible combinations that include Chicago.

Despite the near homogeneity of the four cities' samples with regard to trip distance, the tests of weekday trip elapsed time reject the basic hypothesis in all combinations of cities. Chicago has proportionately fewer trip times in the range below 40 minutes than does Cincinnati, proportionately fewer in the range between 18 and 60 minutes than Houston, and proportionately fewer in the range between 16 and 40 minutes than Los Angeles. Calculation of the 95% confidence bands for the mean weekday trip elapsed time in the four cities show that only Chicago and Houston overlap. The bands for Cincinnati and Los Angeles lie below the range for these two cities.

Tests made on the distribution of weekend trip elapsed times show that one may consider these as homogeneously distributed in all possible city combinations that include Chicago.

Tests of homogeneity with respect to engine-on stops reject the hypothesis decisively in all city combinations. As mentioned in the Cincinnati study, this variable is the most erratically distributed from city to city of any considered. In pairwise combinations, Chicago resembles Houston most closely though even here the test rejects the hypothesis of homogeneity at both α levels.

In testing trip average speed we found that the hypothesis of homogeneity had to be rejected in all cases for weekday and weekend except the weekend pairwise combination of Chicago and Los Angeles. The average speed in Chicago was the slowest of any of the four cities. For weekday trips the value was 22.9 mph versus 23.9 mph in Cincinnati, 25.2 mph in Houston, and 24.8 mph in Los Angeles. A comparison of the 95% confidence bands for this variable shows that Chicago is completely nonoverlapping with the other three cities. The range from the lowest to the highest value in the four bands is from 22.6 mph to 25.4 mph and none of the four overlap any of the others! The significance of this "precision" is touched upon in the next section. Weekend values of trip average speed show the same ordering of cities as do the weekday values. Here, however, there is some slight overlap in the 95% confidence bands for the mean.

The distributions of indoor and outdoor parking were tested twice, first with respect to between trip parking and second with respect to overnight parking. The hypothesis of homogeneity with respect to between trip parking was rejected for the four way combination of cities because of the difference between Chicago and Cincinnati. Chicago was more similar to both Los Angeles and Houston in this regard which is somewhat surprising considering that both Chicago and Cincinnati were surveyed during cold weather. In testing the distribution of overnight parking on weekdays, Chicago was found to be significantly different than Los Angeles but similar to the other two cities. On weekends, the distribution was found to be homogeneous in the four cities.

The final variable tested was overnight fuel tank readings. Here the hypothesis of homogeneity was rejected for both weekdays and weekends. The reason lies in the discrepancy between empty and full readings in the four cities. The distributions of mid-range readings do not vary considerably from city to city.

Conclusions

The tests just described are all based on classical statistical techniques. In all cases the critical value of the test statistic is a function of sample size. The underlying theory in all of these tests is that the larger the sample size, the more "precise" the resulting comparison will be. In the case of the Driving Patterns Survey, sample sizes for all variables are large, whether based on number of trips or number of car days. Nevertheless, they are only finite samples from even larger populations. The number of trips per day in any of these samples constitutes only a miniscule percentage of the total number of trips taken on that day in the city being surveyed. Therefore, the degree of real precision in our results--that is, the degree to which our results are truly representative of the driving behavior of the city--depends crucially on how representative of the overall population the sample is. No measure of the degree of representativeness is available to us. To some extent, the real randomness of the sample must be an article of faith with the statistician in any survey and this holds true for the present study.

We stress this caveat because despite the number of tests described above where the four cities failed to show homogeneity, we do not believe that their failure to do so need necessarily mean that driving behavior is really significantly different in the three cities. If one examines the figures showing distributions of variables in the present and previous volumes from an essentially qualitative standpoint, one cannot help but be impressed by their overall similarity. There are no startling differences between the cities. This is perhaps the most significant finding of the study to date.

APPENDIX

CHICAGO SURVEY PROCEDURES

The survey procedure was designed to obtain data from which typical driving patterns could be derived. Three basic steps were taken in the data gathering phase of the survey: design of the survey sample; selection of the survey participants; and collection of data. Subsequent sections of this Appendix cover each of these steps in detail.

SAMPLE DESIGN

The sample for the Chicago Driving Patterns Survey was designed to obtain data on an adequate number of trips to ensure that description of trip variables would be statistically accurate. Fifty Tachograph recording devices previously employed during the Los Angeles, Houston, and Cincinnati Driving Patterns Surveys were used to collect data from 50 participating automobiles for one week; on the basis of Chicago's population, it was determined that data from 250 vehicles would be a representative sample.

As in the surveys in the other cities, the sample was stratified four ways in terms of residence type (single family and multiple family dwelling) and car ownership (single car and multiple car). These stratification criteria were based on data from the continuing Los Angeles Regional Traffic Study (LARTS), which indicates that trip generation rates for automobiles can be correlated with residence type and car ownership.

The proposed stratification in Los Angeles was based on 1960 Census data. As the study there progressed, however, application forms from prospective participants showed clearly that the 1968 population had changed markedly from the 1960 population with respect to residence type and car ownership. This change necessitated a modification to the stratification of the Los Angeles sample.

Based upon our experience in Los Angeles relative to change in population, it was decided to stratify the sample for the Chicago survey according to data provided by application forms received from prospective participants. Percentages in each of the cells in the matrix in Table A-1 are representative averages of the information obtained from the 19 participating organizations in Chicago.

TABLE A-1

STRATIFICATION OF THE SAMPLE FOR THE CHICAGO DRIVING PATTERNS SURVEY

RESIDENCE TYPE	AUTOMOBILES PER HOUSEHOLD	
	ONE	TWO OR MORE
Single Family	38%	20%
Multiple Family	37%	5%

PARTICIPANT SELECTION

The method by which SDC selected participants in the survey was chosen to obtain a representative cross-section of the Chicago population. A list of large industrial and commercial organizations in the area was provided by the Chicago Association of Commerce and Industry. From this list 35 firms were contacted and briefed on the nature of the survey. Of the firms contacted, 27 agreed to participate.

Individual volunteers from within each company were recruited by means of Information/Questionnaire Packets which were distributed among the employees (see Volume 0, Appendix II). All the organizations were encouraged to seek as many volunteers as possible; however, the number to be solicited as well as the method to be used to distribute the Information/Questionnaire Packets were left to the discretion of each organization. Generally, those organizations with smaller populations (85 to 500 people) chose to canvas all of

their employees for volunteers; those with a larger population (more than 500 people) decided upon some form of random method of distribution, e.g., distribute one packet to every third name in the telephone book, distribute packets to all personnel who parked their automobiles in the company garage, etc.

A total of 6700 packets were distributed within the participating organizations. Of that number 704 individuals volunteered to participate, from which 250 were chosen as the survey sample (see Table A-2).

DATA COLLECTION

The data collection effort in Chicago began on April 21, 1969. Of the 250 individuals chosen as the survey sample, 51 were eliminated for various reasons--mechanical incompatibility between the volunteer's automobile and the Tachograph instrument, failure of individuals to report for the installation, mechanical condition of car, etc. Of the 199 actual installations made, 28 did not provide usable information because of mechanical failures either in the vehicle or the Tachograph.

TABLE A-2
RECRUITING PARTICIPANTS

<u>ORGANIZATION</u>	<u>QUESTIONNAIRES DISTRIBUTED</u>	<u>VOLUNTEERS</u>	<u>SURVEY SAMPLE</u>
A. B. Dick Company	200	0	0
Acme Resin Company	100	0	0
Alcoa Castings Company	100	0	0
Allied Radio, Inc.	300	0	0
Allis-Chalmers	200	53	20
American Medical Association	200	22	10
American Oil Company	600	77	20
Amphenol Connector Division/ Bunker-Ramo Corporation	200	22	10
Armour & Company	200	19	10
Bankers Life & Casualty Company	600	21	10
Bell & Howell Company	200	40	20
Continental Can Company	250	55	20
Continental Casualty Company	100	34	10
Federal Sign & Signal Corporation	200	13	10
Formold Plastics, Inc.	200	0	0
IIT Research Institute	500	36	10
Illinois Tool Works, Inc.	150	16	10
Inland Steel Company	100	51	10
International Harvester Company	500	87	20
Jewel Companies, Inc.	200	20	15
Prudential Insurance Company of America	200	11	5
The Seeburg Corporation	400	0	0
The Sherwin-Williams Company	200	41	10
Spiegel, Inc.	200	44	20
University of Illinois	200	42	10
Vapor Corporation	200	0	0
Western Electric Company, Inc.	<u>200</u>	<u>0</u>	<u>0</u>
TOTALS	6700	704	250

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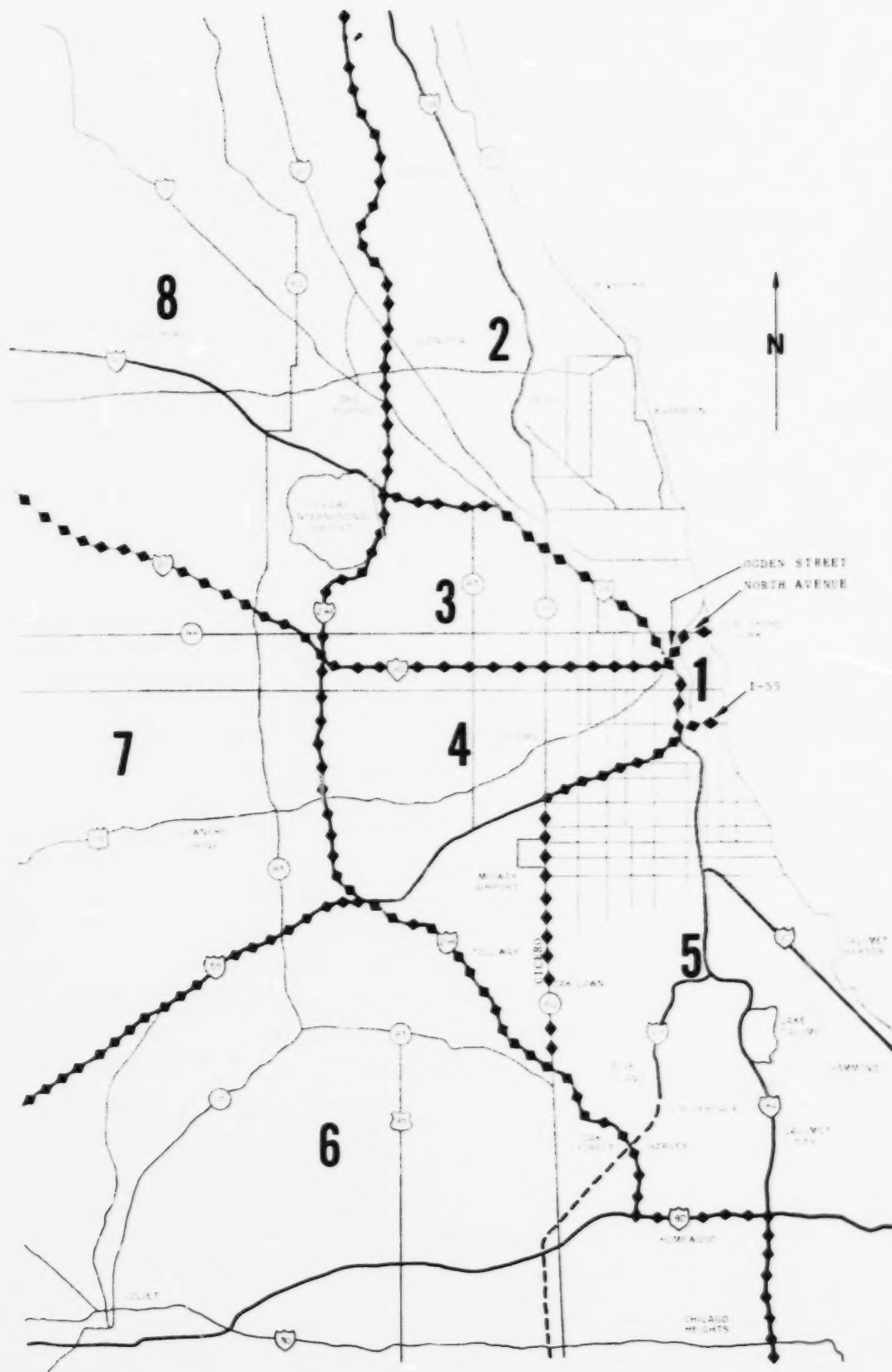


FIGURE A-1
CHICAGO DRIVING PATTERNS SURVEY
SURVEY ZONES